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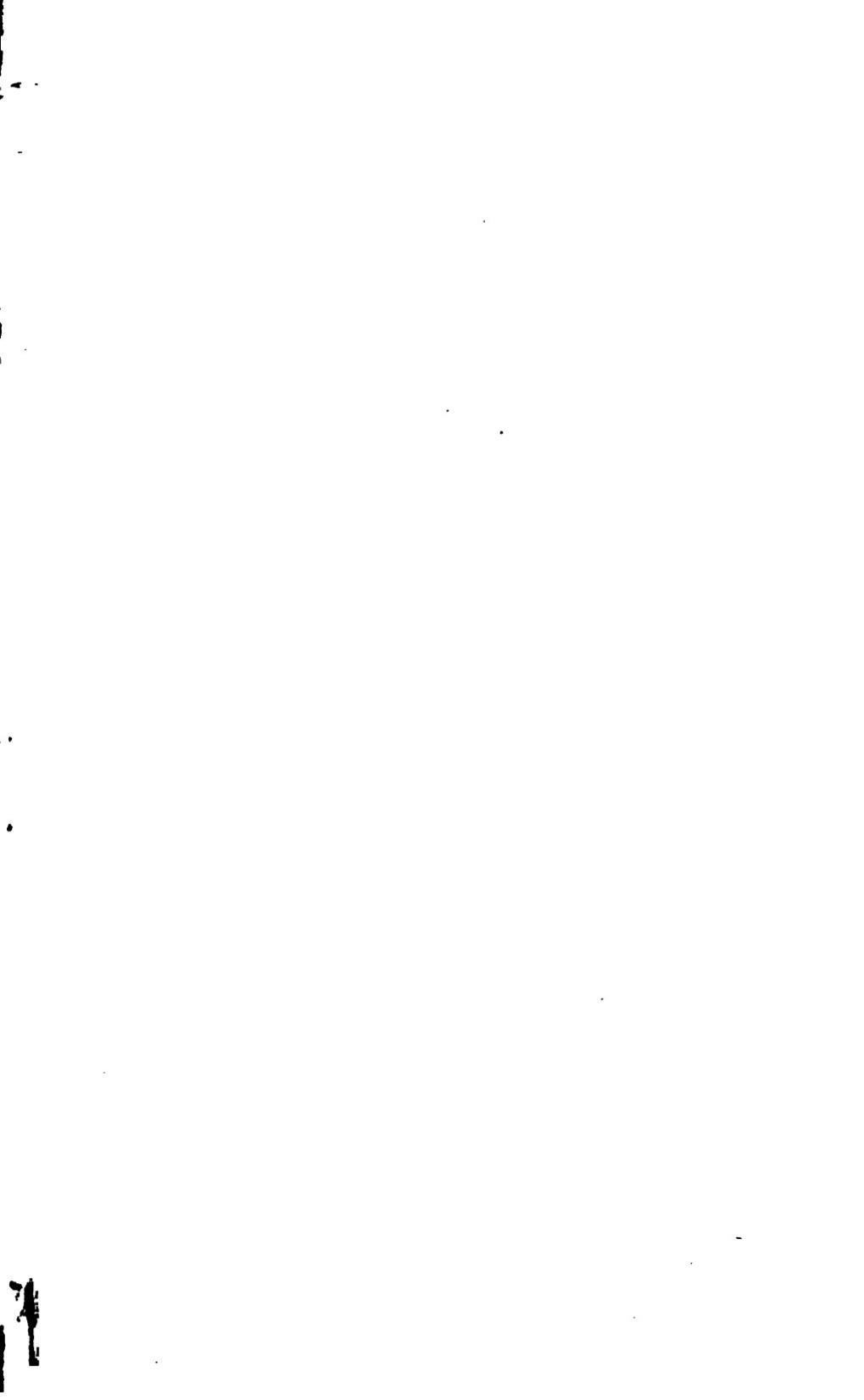
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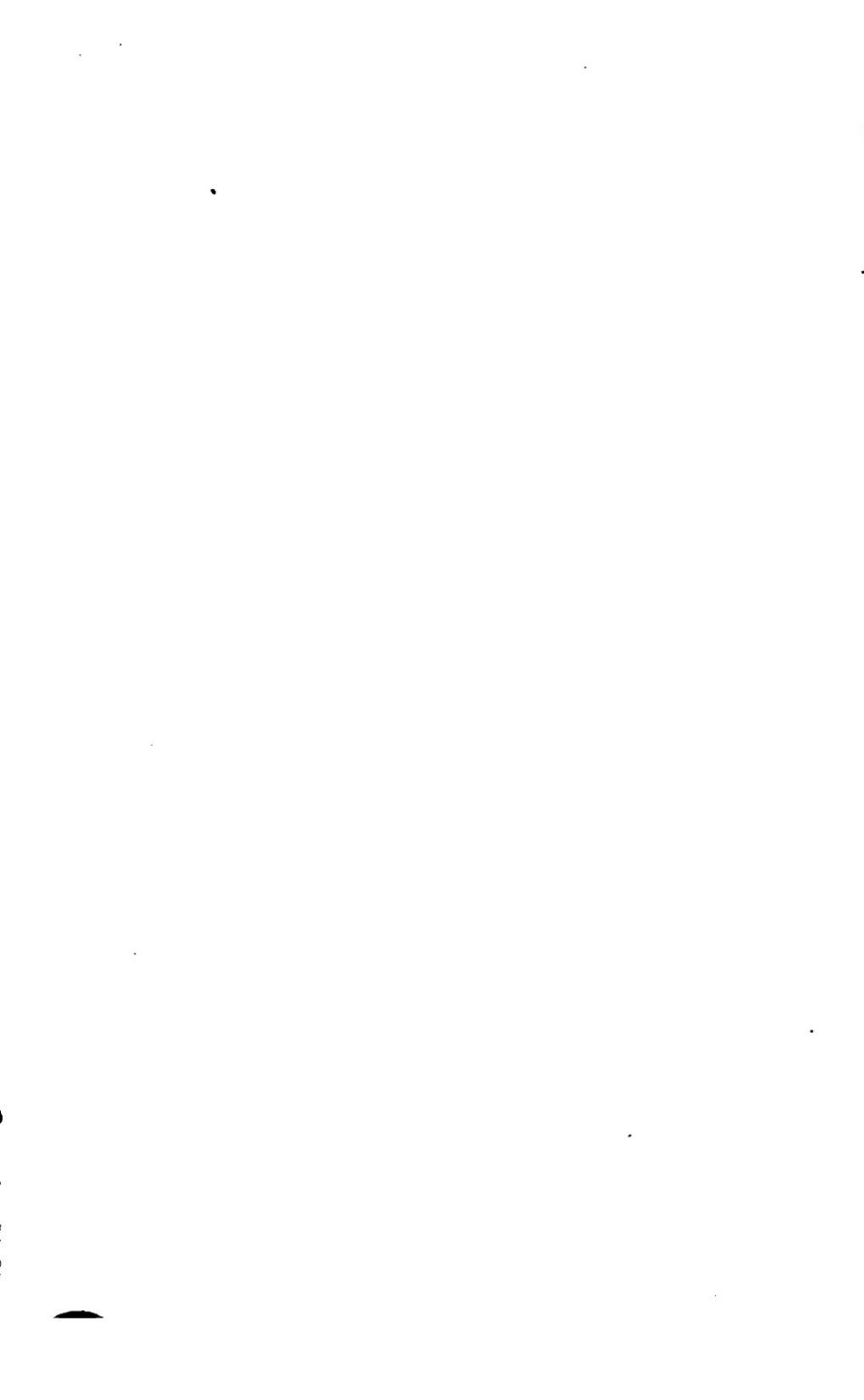
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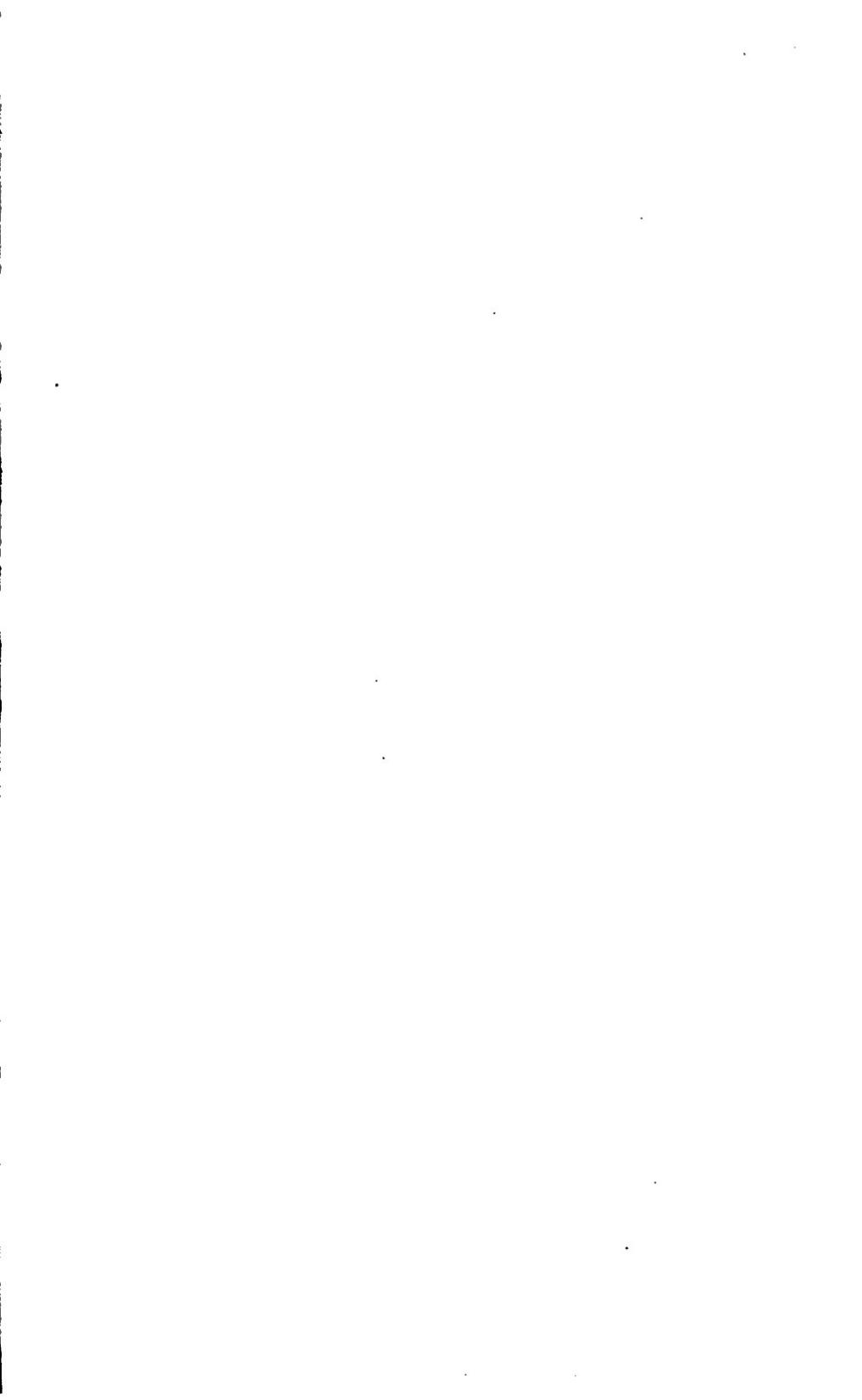
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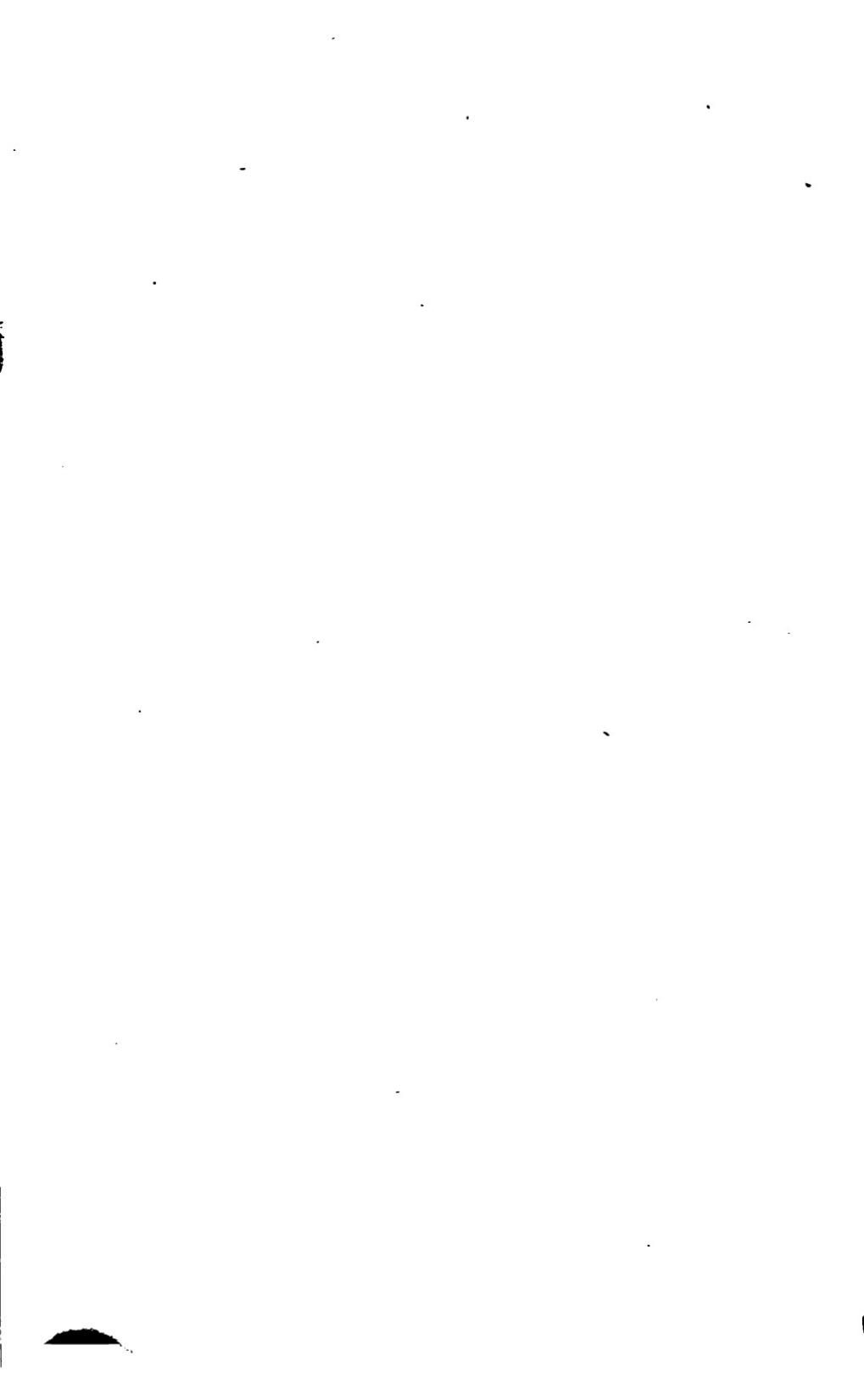
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PROCEEDINGS

OF

THE AMERICAN ASSOCIATION



FOR THE THIRTY-NINTH MEETING,

HELD AT

INDIANAPOLIS, INDIANA.

AUGUST, 1890.

SALEM:
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ERRATA.

Page 55, Mr. Warner's paper. Add to perpendicular lines, The word digits is here used for digit values of s.

Page 55, line 13 from bottom. For "add" read subtract.

Page 55, line 10 from bottom. The minus sign should precede 8t.

Page 56, last line but one in the example. For "D" read D₂.

Page 69, line 10, Prof. Abbe's address. Take out the words "I understand that an earnest effort is being" and substitute the following:— the work of Carl Barus is an earnest of efforts.

Page 347, line 3, Dr. Wilder's paper. For "Herve's" read Hervé's.

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OF THE
INDIANAPOLIS MEETING.**

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- H. Anthropology**—FRANK BAKER of Washington, D. C.
- I. Economic Science and Statistics**—J. RICHARDS DODGE of Washington, D. C.

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SPECIAL COMMITTEES OF THE ASSOCIATION.¹

1. Committee on Indexing Chemical Literature.

H. CARRINGTON BOLTON of New York,	A. A. JULIEN of New York,
F. W. CLARKE of Washington,	J. W. LANGLEY of Ann Arbor,
A. R. LEEDS of Hoboken,	A. B. PRESCOTT of Ann Arbor.

2. Committee on Anatomical Nomenclature, with Special reference to the Brain.

B. G. WILDER of Ithaca,	T. B. STOWELL of Cortland,
HENRY F. OSBORN of Princeton,	HARRISON ALLEN of Philadelphia,
FRANK BAKER of Washington.	

3. Committee to apply to Congress for a Reduction of the Tariff on Scientific Books and Apparatus.

E. D. CORP of Philadelphia,	J. R. EASTMAN of Washington,
JOHN S. BILLINGS of Washington.	

4. Committee to memorialize Congress to take steps for the Preservation of Archaeologic Monuments on the public lands.

MISS ALICE C. FLETCHER of Cambridge,	MRS. M. E. STEVENSON of Washington.
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5. Committee on Water Analysis.

G. C. CALDWELL of Ithaca,	J. W. LANGLEY of Ann Arbor,
J. A. MYERS of Agricultural Coll., Miss.,	W. P. MASON of Troy,
R. B. WARDER of Washington,	W. H. SHAMAN of Washington.

6. Committee on the Maintenance of Timberlands and on the Development of the Natural Resources of the Country.

T. C. MENDENHALL of Washington,	C. E. BESSEY of Lincoln,
E. W. HILGARD of Berkley,	B. E. FERNOW of Washington,
WILLIAM SAUNDERS of Ottawa.	

7. Committee on Spelling and Pronouncing Chemical Terms.

THOMAS H. NORTON of Cincinnati,	JAMES LEWIS HOWE of Louisville,
H. CARRINGTON BOLTON of New York,	EDWARD HART of Easton.

8. Honorary Agent of Transportation to act with the Local Committees.

P. H. DUDLEY of New York.

9. Auditors.

HENRY WHEATLAND of Salem,	THOMAS MEEHAN of Germantown.
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¹ All Committees are expected to present their reports to the COUNCIL not later than the fourth day of the meeting. Committees sending their reports to the Permanent Secretary one month before a meeting can have them printed for use at the meeting.

OFFICERS ELECTED
FOR THE
WASHINGTON MEETING.

AUGUST, 1891.

PRESIDENT.

ALBERT B. PRESCOTT, Ann Arbor, Mich.

VICE PRESIDENTS.

- A. Mathematics and Astronomy**—E. W. HYDE, Cincinnati, Ohio.
- B. Physics**—F. E. NIPPER, St. Louis, Mo.
- C. Chemistry**—R. C. KEDZIE, Agricultural College, Mich.
- D. Mechanical Science and Engineering**—THOMAS GRAY, Terre Haute, Ind.
- E. Geology and Geography**—J. J. STEVENSON, New York.
- F. Biology**—J. M. COULTER, Crawfordsville, Ind.
- H. Anthropology**—JOSEPH JASTROW, Madison, Wis.
- I. Economic Science and Statistics**—EDMUND J. JAMES, Philadelphia, Pa.

PERMANENT SECRETARY.

F. W. PUTNAM, Cambridge (office Salem), Mass.

GENERAL SECRETARY.

HARVEY W. WILKEY, Washington, D. C.

SECRETARY OF THE COUNCIL.

AMOS W. BUTLER, Brookville, Ind.

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- A. Mathematics and Astronomy**—E. D. PRESTON, Washington, D. C.
- B. Physics**—A. McFARLANE, Austin, Texas.
- C. Chemistry**—T. H. NORTON, Cincinnati, Ohio.
- D. Mechanical Science and Engineering**—WILLIAM KENT, New York, N. Y.
- E. Geology and Geography**—W. J. McGEE, Washington, D. C.
- F. Biology**—A. J. COOK, Agricultural College, Michigan.
- H. Anthropology**—W. H. HOLMES, Washington, D. C.
- I. Economic Science and Statistics**—B. E. FERNOW, Washington.

TREASURER.

WILLIAM LILLY, Mauch Chunk, Pa.

MEETINGS.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIST. SECTY.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		B. Silliman, Jr.*
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	I. C. Beck,*		C. B. Trego,*
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*		J. D. Whitney, M. B. Williams,*
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, Jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, Jr.,*		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	O. P. Hubbard,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, Jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,*†	Jeffries Wyman,*		B. Silliman, Jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SECY.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter B. Johnson,*	Jeffries Wyman.*	
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1	A. L. Elwyn.*	
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* ²		L. R. Gibbs, 3	S. J. Ravenel,* ⁴	
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*	▲ A. L. Elwyn.*	
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. F. Baird,* ⁵	S. F. Baird,*	
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,* ⁶	S. F. Baird,*	
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* ⁷	S. F. Baird,*	
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte,* ⁸
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 13, 1857,	Montreal, Canada,	Alexis Caswell,* ⁹		John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 29, 1858,	Baltimore, Md.,	Alexis Caswell,* ¹⁰		John E. Hollbrook,* ¹¹	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*		Edward Hitchcock,* ¹²	William Chauncy,*	Joseph Lovering,
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,*		B. A. Gould,	Joseph LeConte,	A. L. Elwyn.*
15th	Aug. 15, 1860,	Buffalo, N. Y.,	F. A. P. Barnard,*		A. A. Gould,* ¹³	Elias Loomis, 13	Joseph Lovering,
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,		Wolcott Gibbs,	C. S. Lyman,	A. L. Elwyn.* ¹⁴
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,		Charles Whittlesey,*	Simon Newcomb, 14	Joseph Lovering,
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*		O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16		T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Aaa Gray,*		G. F. Barker,	F. W. Putnam,	A. L. Elwyn.* ¹⁵
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*		Alex. Winchell,*	E. S. Morse,	Joseph Lovering,
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,		A. H. Worthen,* ¹⁶	C. A. White,	F. W. Putnam,
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*		C. S. Lyman,*	A. C. Hamlin,	F. W. Putnam,
							W. S. Vaux,*

1. In place of Jeffries Wyman, *not present*.
 2. In place of Joseph Henry, *not present*.
 3. In place of E. C. Herrick, *not present*.
 4. In place of A. L. Elwyn, *not present*.
 5. In place of J. W. Bailey, *deceased*.
 6. In place of E. C. Herrick, *not present*.
 7. In place of J. D. Dana, *not present*.
 8. In place of A. L. Elwyn, *not present*.
 9. In place of J. W. Bailey, *deceased*.
 10. In place of Jeffries Wyman, *not present*.
 11. In place of Wm. Clarendon, *not to be present*.
 12. In place of Wm. Clarendon, *not present*.
 13. In place of W. P. Trowbridge, *not present*.
 14. In place of A. P. Rockwell, *called home 1st day*.
 15. In place of Joseph Lovering, *in Europe*.
 16. In place of Wm. Clarendon, *too ill to be present*.
 17. In place of C. F. Hartt, *in Brazil*.
 * Deceased. † Not present at the meeting.

MEETINGS.

MEETINGS AND OFFICERS OF THE ASSOCIATION (Continued).

MEET- ING.	DATE	PLACE	PRESIDENT	VICE PRESIDENT, SECTION A.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.		CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.
					GENERAL SECRETARY.	SECRETARY OF SECTION A.		
24th	Aug. 11, 1875.	Detroit, Mich., Buffalo, N. Y., Nashville, Tenn.	J. E. Hilliard,* W. B. Rogers,* S. Newcomb,	H. A. Newton, C. A. Young, R. H. Thurston, ¹	J. W. Dawson, E. S. Morse, O. C. Marsh,	S. W. Johnson, G. F. Barker, N. T. Lapkin,	L. H. Morgan,* L. H. Morgan, Daniel Wilson, ²	R. H. Ward, R. H. Ward,
26th	Aug. 23, 1876.	St. Louis, Mo., Bar Harbor, N. Y., Boston, Mass., Cincinnati, Ohio,	O. C. Marsh, G. F. Barker, L. H. Morgan,* G. J. Brush,	R. H. Thurston, ³ S. P. Langley, Asaph Hall, Wm. Hartness, ⁴	Aug. R. Grose, J. W. Powell, Alex. Agassiz, E. T. Cox, ⁵	F. W. Clarke, F. W. Clarke, J. M. Ordway, G. C. Caldwell, ⁶	R. H. Ward, ⁷ Daniel Wilson, ⁸ J. W. Powell, G. Mallory, ⁹	R. H. Ward, R. H. Ward,
27th	Aug. 29, 1877.							
22th	Aug. 21, 1878.							
26th	Aug. 27, 1879.							
29th	Aug. 26, 1880.							
30th	Aug. 27, 1881.							

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.		SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.
			GENERAL SECRETARY.	SECRETARY OF SECTION A.				
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse, A. V. Wright,	Albert H. True, H. C. Bolton,	H. C. Bolton, P. Schweitzer, Wm. H. Dall,	F. W. Clarke, O. T. Mason, T. O. Summers, Jr., ¹⁰	F. W. Putnam, E. W. Morley, G. J. Engelmann, ¹¹	W. S. Vanz,*
F. W. Putnam,	T. C. Mendenhall,	A. V. Wright,	H. C. Bolton,	George Ladd, W. H. Dall, ⁶	A. P. S. Stuart, W. R. Nichols, ⁸	— ²	— ²	W. S. Vanz, ¹²
F. W. Putnam,	Aug. R. Grose,	H. C. Bolton,	E. E. Nipher,	C. V. Riley,	C. E. Monroe, Wm. Saunders, ¹⁰	J. G. Henderson, A. B. Hervey, J. G. Henderson, A. B. Hervey, J. G. Henderson, ¹³	J. G. Henderson, A. B. Hervey, W. H. Seaman, ¹¹	W. S. Vanz, ¹²
F. W. Putnam,	H. C. Bolton,	E. E. Nipher,	J. K. Rees,					
F. W. Putnam,	H. C. Bolton, ⁹	J. K. Rees,	H. H. Mason,					
F. W. Putnam,	J. K. Rees,							
F. W. Putnam,	C. V. Riley,		E. T. Tupper, ¹⁰					

¹ In the absence of E. C. Pickering.² In the absence of Ira Remsen.³ In the absence of A. C. Weber.⁴ In the absence of George Little.⁵ In the absence of A. M. Mayr.⁶ In the absence of John Trowbridge.⁷ Deceased.⁸ In the absence of G. S. Blackie.⁹ In the absence of George Little.¹⁰ In the absence of George Engelmann.¹¹ In the absence of W. R. Nichols.¹² In place of H. W. Wiley, called away.¹³ Not present.

MEETINGS.

XXI

MEETINGS AND OFFICERS OF THE ASSOCIATION. (Continued.)

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				VICE PRESIDENTS.			
				Section A.	Section B.	Section C.	Section D.	Section A.	Section B.	Section C.	Section D.
31st	Aug. 28, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers, ¹	T. C. Mendenhall,	H. B. Bolton,	W. P. Trowbridge,	E. T. Cox,	C. H. Hitchcock,	G. C. Wood,	Section E.
2nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Vol-en-Wood,	N. H. Winchell,	R. H. Thurston,	N. H. Lankford,	
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Leesley,	H. T. Eddy,	J. T. Trowbridge,	J. W. Minot,	J. Burkitt Webb,	Edward Otton,	J. Burkitt Webb,	N. T. Lupion, ²	
34th	Aug. 26, 1885.	A. Ann Arbor, Mich.	H. A. Newton,	W. Harkness, ³	S. P. Langley, ⁴	J. W. Willey, ⁵	O. Chanute,	T. C. Chamberlin, ⁶	G. K. Gilbert, ⁷	G. K. Gilbert, ⁸	
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs, ⁹	C. F. Brackett, ¹⁰	H. W. Wiley, ¹¹	A. B. Preseott, ¹²	E. B. Coxe, ¹³	J. R. Eastman, ¹⁴	J. R. Eastman, ¹⁵	
36th	Aug. 10, 1887.	New York, N. Y.	S. P. Langley, ¹⁶								
Section F.	Section G.	VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF THE SECTIONS.		
		Section H.	Section I.	Section J.	Section L.	Section H.	Section I.	Section A.	SECRETARIES OF THE SECTIONS.		
W. H. Dall,	A. H. Tuttle,	Alex. Winchell, [*]	E. B. Elliott, [*]	F. W. Putnam,	Wm. Saunders,	J. R. Eastman,	H. T. Eddy,	C. S. Hastings,	William Lilly, ^{**}	John Cummings, [*]	Section B.
W. J. Beat,	J. D. Cox,	J. D. Mason, [*]	F. B. Hough, [*]	E. W. Putnam,	J. R. Eastman,	Alfred Springer, [*]	G. W. Hough, [*]	John Nipher, [*]	William Lilly, ^{**}	C. W. Smiley, [*]	
R. D. Cope,	T. G. Wormley,	E. S. Morse,	F. B. Hough, [*]	F. W. Putnam,	John Eaton,	C. S. Minot, [*]	G. W. Hough, [*]	E. B. Hodges, [*]	William Lilly, ^{**}	E. W. Thomas, [*]	
T. J. Burrill, ¹⁷	S. H. Grage,	J. O. Dorsey, ¹⁸	E. W. Putnam,	E. W. Putnam,	E. W. Putnam,	S. G. Williams, [*]	E. W. Hough, [*]	J. F. Thomas, [*]	William Lilly, ^{**}	H. S. Carhart, [*]	
H. P. Bowditch, ¹⁹	— ²⁰	H. Hale,	J. Cummings, [*]	F. W. Putnam,	C. S. Minot,	W. H. Peetee,	H. S. Carhart, [*]	C. Leo Mees, [*]	William Lilly, ^{**}	H. M. Paul, [*]	
W. G. Farlow, ²¹	— ²²	D. G. Brinton, ²³	H. E. Alvord,	F. W. Putnam,	W. H. Peetee,	J. C. Arthur, [*]	H. E. Alvord, [*]	F. B. Hough, [*]	William Lilly, ^{**}	W. R. Lazebny, [*]	
SECRETARIES OF THE SECTIONS.				SECRETARIES OF THE SECTIONS.				SECRETARIES OF THE SECTIONS.			
Section G.	Section H.	Section I.	Section J.	Section L.	Section D.	Section E.	Section F.	Section G.	Section H.	Section I.	Treasurer.
Alfred Springer, ²⁴	J. B. Webb, ²⁵	H. S. Williams, ²⁶	Wm. Osler, ²⁷	Robt. Brown, Jr., ²⁸	O. T. Mason, ²⁹	Carl Seiler, ³⁰	G. H. Perkins, ³¹	F. B. Hough, ³²	William Lilly, ^{**}	John Cummings, [*]	Section A.
J. W. Langley, ¹⁰	J. B. Webb, ¹¹	A. A. Julian, ³³	S. A. Forbes, ³⁴	Carl Seiler, ³⁵	G. H. Perkins, ³⁶	G. H. Perkins, ³⁷	G. H. Perkins, ³⁸	G. W. Hough, [*]	William Lilly, ^{**}	C. W. Smiley, [*]	
H. Carmichael, ¹²	C. B. H. Woolbury, ¹³	E. A. Smith, ³⁹	C. E. Bessey, ⁴⁰	G. H. Perkins, ⁴¹	G. H. Perkins, ⁴²	G. H. Perkins, ⁴³	G. H. Perkins, ⁴⁴	G. W. Hough, [*]	William Lilly, ^{**}	C. W. Smiley, [*]	
F. P. Dunnington, ¹⁴	C. J. H. Woolbury, ¹⁵	G. K. Gilbert, ⁴²	J. A. Lintner, ⁴³	W. H. Wilmsley, ⁴⁴	W. H. Wilmsley, ⁴⁵	Erm. A. Smith, ⁴⁶	Erm. A. Smith, ⁴⁷	Erm. A. Smith, ⁴⁸	William Lilly, ^{**}	H. E. Alvord, [*]	
W. McMurtry, ¹⁶	William Kent, ¹⁷	E. W. Claypole, ⁴⁸	J. C. Arthur, ⁴⁹	J. C. Arthur, ⁵⁰	J. C. Arthur, ⁵¹	A. W. Butler, ⁵²	A. W. Butler, ⁵³	A. W. Butler, ⁵⁴	William Lilly, ^{**}	W. R. Lazebny, [*]	
C. S. Mabery, ⁵⁵	G. M. Bond, ⁵⁶	W. M. Davis, ⁵⁷	J. H. Constock, ⁵⁸			C. C. Abbott, ⁵⁹	C. C. Abbott, ⁶⁰	C. C. Abbott, ⁶¹	William Lilly, ^{**}		
7 Absent, but place was not filled.				13 In the absence of R. B. Warner.				19 In the absence of W. B. Warner.			
1 In the absence of Davis Wilson.				14 In the absence of W. H. Holmes.				20 In place of C. C. Abbott, now present.			
2 In the absence of C. B. Drury.				15 In the absence of W. H. Holmes.				21 In place of C. C. Abbott, now present.			
3 In the absence of C. B. Drury.				16 In the absence of C. J. M. Van Vleck.				22 In place of C. C. Abbott, now present.			
4 In the absence of C. E. Dutson.				17 In place of C. C. Abbott, now present.				23 In place of C. C. Abbott, now present.			
5 In the absence of C. S. Mabery.				18 In the absence of W. H. Nichols.				24 In the absence of C. H. Chamberlin.			
6 P. W. Hough, was called home, and J. R. Dodge				19 In the absence of C. W. Wilder.				25 In the absence of C. W. Wilder.			
7 In the absence of C. W. Wilder.				20 In place of W. H. Nichols.				26 In place of W. H. Nichols.			
8 In the absence of C. K. Weeks.				21 In the absence of C. J. M. Van Vleck.				27 Absent; R. B. Warner acted as Secy Pro tem.			
9 In the absence of C. K. Weeks.				22 In the absence of C. C. Abbott, now present.				28 In place of C. C. Abbott, absent.			
10 W. M. McMurtie, last three days of meeting.				23 In the absence of C. C. Abbott, now present.				29 In place of C. C. Abbott, absent.			
11 W. M. McMurtie, last three days of meeting.				30 In the absence of C. C. Abbott, now present.				31 In the absence of C. C. Abbott, now present.			
12 W. M. McMurtie, last three days of meeting.				32 In the absence of C. C. Abbott, now present.				33 In the absence of C. C. Abbott, now present.			
13 W. M. McMurtie, last three days of meeting.				34 In the absence of C. C. Abbott, now present.				35 In the absence of C. C. Abbott, now present.			
14 W. M. McMurtie, last three days of meeting.				36 In the absence of C. C. Abbott, now present.				37 In the absence of C. C. Abbott, now present.			
15 W. M. McMurtie, last three days of meeting.				38 In the absence of C. C. Abbott, now present.				39 In the absence of C. C. Abbott, now present.			
16 W. M. McMurtie, last three days of meeting.				40 In the absence of C. C. Abbott, now present.				41 In the absence of C. C. Abbott, now present.			
17 W. M. McMurtie, last three days of meeting.				42 In the absence of C. C. Abbott, now present.				43 In the absence of C. C. Abbott, now present.			
18 W. M. McMurtie, last three days of meeting.				44 In the absence of C. C. Abbott, now present.				45 In the absence of C. C. Abbott, now present.			
19 W. M. McMurtie, last three days of meeting.				46 In the absence of C. C. Abbott, now present.				47 In the absence of C. C. Abbott, now present.			
20 W. M. McMurtie, last three days of meeting.				48 In the absence of C. C. Abbott, now present.				49 In the absence of C. C. Abbott, now present.			
21 W. M. McMurtie, last three days of meeting.				50 In the absence of C. C. Abbott, now present.				51 In the absence of C. C. Abbott, now present.			
22 W. M. McMurtie, last three days of meeting.				52 In the absence of C. C. Abbott, now present.				53 In the absence of C. C. Abbott, now present.			
23 W. M. McMurtie, last three days of meeting.				54 In the absence of C. C. Abbott, now present.				55 In the absence of C. C. Abbott, now present.			
24 W. M. McMurtie, last three days of meeting.				56 In the absence of C. C. Abbott, now present.				57 In the absence of C. C. Abbott, now present.			
25 W. M. McMurtie, last three days of meeting.				58 In the absence of C. C. Abbott, now present.				59 In the absence of C. C. Abbott, now present.			
26 W. M. McMurtie, last three days of meeting.				60 In the absence of C. C. Abbott, now present.				61 In the absence of C. C. Abbott, now present.			
27 W. M. McMurtie, last three days of meeting.				62 In the absence of C. C. Abbott, now present.				63 In the absence of C. C. Abbott, now present.			
28 W. M. McMurtie, last three days of meeting.				64 In the absence of C. C. Abbott, now present.				65 In the absence of C. C. Abbott, now present.			
29 W. M. McMurtie, last three days of meeting.				66 In the absence of C. C. Abbott, now present.				67 In the absence of C. C. Abbott, now present.			
30 W. M. McMurtie, last three days of meeting.				68 In the absence of C. C. Abbott, now present.				69 In the absence of C. C. Abbott, now present.			
31 W. M. McMurtie, last three days of meeting.				70 In the absence of C. C. Abbott, now present.				71 In the absence of C. C. Abbott, now present.			
32 W. M. McMurtie, last three days of meeting.				72 In the absence of C. C. Abbott, now present.				73 In the absence of C. C. Abbott, now present.			
33 W. M. McMurtie, last three days of meeting.				74 In the absence of C. C. Abbott, now present.				75 In the absence of C. C. Abbott, now present.			
34 W. M. McMurtie, last three days of meeting.				76 In the absence of C. C. Abbott, now present.				77 In the absence of C. C. Abbott, now present.			
35 W. M. McMurtie, last three days of meeting.				78 In the absence of C. C. Abbott, now present.				79 In the absence of C. C. Abbott, now present.			
36 W. M. McMurtie, last three days of meeting.				80 In the absence of C. C. Abbott, now present.				81 In the absence of C. C. Abbott, now present.			
37 W. M. McMurtie, last three days of meeting.				82 In the absence of C. C. Abbott, now present.				83 In the absence of C. C. Abbott, now present.			
38 W. M. McMurtie, last three days of meeting.				84 In the absence of C. C. Abbott, now present.				85 In the absence of C. C. Abbott, now present.			
39 W. M. McMurtie, last three days of meeting.				86 In the absence of C. C. Abbott, now present.				87 In the absence of C. C. Abbott, now present.			
40 W. M. McMurtie, last three days of meeting.				88 In the absence of C. C. Abbott, now present.				89 In the absence of C. C. Abbott, now present.			
41 W. M. McMurtie, last three days of meeting.				90 In the absence of C. C. Abbott, now present.				91 In the absence of C. C. Abbott, now present.			
42 W. M. McMurtie, last three days of meeting.				92 In the absence of C. C. Abbott, now present.				93 In the absence of C. C. Abbott, now present.			
43 W. M. McMurtie, last three days of meeting.				94 In the absence of C. C. Abbott, now present.				95 In the absence of C. C. Abbott, now present.			
44 W. M. McMurtie, last three days of meeting.				96 In the absence of C. C. Abbott, now present.				97 In the absence of C. C. Abbott, now present.			
45 W. M. McMurtie, last three days of meeting.				98 In the absence of C. C. Abbott, now present.				99 In the absence of C. C. Abbott, now present.			
46 W. M. McMurtie, last three days of meeting.				100 In the absence of C. C. Abbott, now present.				101 In the absence of C. C. Abbott, now present.			
47 W. M. McMurtie, last three days of meeting.				102 In the absence of C. C. Abbott, now present.				103 In the absence of C. C. Abbott, now present.			
48 W. M. McMurtie, last three days of meeting.				104 In the absence of C. C. Abbott, now present.				105 In the absence of C. C. Abbott, now present.			
49 W. M. McMurtie, last three days of meeting.				106 In the absence of C. C. Abbott, now present.				107 In the absence of C. C. Abbott, now present.			
50 W. M. McMurtie, last three days of meeting.				108 In the absence of C. C. Abbott, now present.				109 In the absence of C. C. Abbott, now present.			
51 W. M. McMurtie, last three days of meeting.				110 In the absence of C. C. Abbott, now present.				111 In the absence of C. C. Abbott, now present.			

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.
37th.	Aug. 14, 1888.	Cleveland, Ohio.	J. W. Powell.
38th.	Aug. 26, 1889.	Toronto, Ontario.	T. C. Mendenhall.
39th.	Aug. 19, 1890.	Indianapolis, Ind.	G. L. Goodale.

VICE PRESIDENTS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
Ormond Stone. R. S. Woodward. S. C. Chandler.	A. A. Michelson. H. S. Carhart. Cleveland Abbe.	C. E. Munroe. W. L. Dudley. R. B. Warder.	C. J. H. Woodbury. James E. Denton. James E. Denton.

SECTION E.	SECTION F.	SECTION G.	SECTION H.
George H. Cook. Charles A. White. John C. Branner.	C. V. Riley. Geo. L. Goodale. C. S. Minot.	C. C. Abbott. Garrick Mallery. Frank Baker.	C. W. Smiley. Charles S. Hill. J. Richards Dodge.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF COUNCIL.	TREASURER.
F. W. Putnam. F. W. Putnam. F. W. Putnam.	Julius Pohlman. C. Leo Mees. H. C. Bolton.	C. Leo Mees. H. C. Bolton. H. W. Wiley.	William Lilly. William Lilly. William Lilly.

SECRETARIES OF SECTIONS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
C. C. Doolittle. G. C. Comstock. W. B. Beman.	A. Macfarlane. E. L. Nichols. E. M. Avery.	W. L. Dudley. Edward Hart. W. A. Noyes.	Arthur Bearisley. W. B. Warner. Thomas Gray.

SECTION E.	SECTION F.	SECTION G.	SECTION H.
John C. Branner. John C. Branner. Samuel Calvin.	B. H. Fernow. A. W. Butler. J. M. Coulter.	Frank Baker. W. M. Beauchamp. Joseph Jastrow.	Charles S. Hill. J. R. Dodge. B. E. Fernow.

MEETINGS.	PLACE.	YEAR.	MEMBERS IN ATTEND- ANCE.	NUMBER OF MEMBERS.
1.	Philadelphia	1848	?	461
2.	Cambridge	1849	?	540
3.	Charleston	1850	?	623
4.	New Haven	1850	?	704
5.	Cincinnati	1851	87	800
6.	Albany	1851	194	769
7.	Cleveland	1853	?	940
8.	Washington	1854	168	1004
9.	Providence	1855	166	605
10.	2nd Albany	1856	381	722
11.	Montreal	1857	351	946
12.	Baltimore	1858	190	963
13.	Springfield	1859	190	862
14.	Newport	1860	135	644
15.	Buffalo	1866	79	637
16.	Burlington	1867	73	415
17.	Chicago	1868	259	686
18.	Salem	1869	244	511
19.	Troy	1870	188	536
20.	Indianapolis	1871	196	668
21.	Dubuque	1871	164	610
22.	Portland	1873	195	670
23.	Hartford	1874	224	722
24.	Detroit	1875	165	807
25.	2nd Buffalo	1876	215	867
26.	Nashville	1877	173	953
27.	St. Louis	1878	134	962
28.	Saratoga	1879	256	1030
29.	Boston	1880	997	1555
30.	2nd Cincinnati	1881	500	1099
31.	2nd Montreal	1882	937	1923
32.	Minneapolis	1883	328	2033
33.	2nd Philadelphia	1884	1961*	1961
34.	Ann Arbor	1885	364	1956
35.	3d Buffalo	1886	445	1886
36.	New York	1887	729	1956
37.	2nd Cleveland	1888	343	1964
38.	Toronto	1889	424	1952
39.	2d Indianapolis.	1890	384	1944

*Including members of the British Association and other foreign guests.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

A N A C T

To INCORPORATE THE "AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

SECTION 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

SECTION 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

SECTION 4. This act shall take effect upon its passage.

HOUSE OF REPRESENTATIVES, March 10, 1874.

Passed to be enacted,

JOHN E. SANFORD, Speaker.

IN SENATE, March 17, 1874.

Passed to be enacted,

March 19, 1874.

GEO. B. LORING, President.

Approved,

W. B. WASHBURN.

SECRETARY'S DEPARTMENT,

Boston, April 8, 1874.

A true copy, Attest:

DAVID PULSIFER,

Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

ART. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been re-elected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

discussions and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following sub-committees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

ART. 19. The Nominating Committee shall consist of the Council, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

ART. 21. A General Session shall be held at 10 o'clock A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy*; B, *Physics*; C, *Chemistry, including its application to agriculture and the arts*; D, *Mechanical Science and Engineering*; E, *Geology and Geography*; F, *Biology*; [G, united to section F]; H, *Anthropology*; I, *Economic Science and Statistics*. The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

ADMISSION FEE AND ASSESSMENTS.

ART. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

ART. 35. The annual assessment for members and fellows shall be three dollars.

ART. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

ART. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

ACCOUNTS.

ART. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

ALTERATIONS OF THE CONSTITUTION.

ART. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
 2. Formalities of welcome of the Association as may be arranged by the Local Committee.
 3. Report of the list of papers entered and their reference to the Sections.
 4. Other reports.
 5. Announcements of arrangements by the Local Committee.
 6. Announcements of Elections by the Council.
 7. Unenumerated business.
 8. Adjournment to meet in Sections.
- This order, so far as applicable, to be followed in subsequent General Sessions.

M E M B E R S
OF THE
AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE.¹

P A T R O N S.²

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28) F E
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

M E M B E R S.³

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abert, S. Thayer, 1108 G St., N. W., Washington, D. C. (80). A B D E I
Abrey, George Burchett, C.E., Toronto, Ontario, Can. (88).
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Adriance, John S., Superintendent Gondolo Taunin Co., Huntingdon, Pa.
(39). C
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

¹ The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

² Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications.

The names of Patrons are to remain permanently on the list.

³ Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

- Allderdice, Wm. H., Ass't Eng. U. S. N., U. S. Naval Academy, Annapolis, Md. (38). D
- Allen, J. M., Hartford, Conn. (22). D
- Allen, W. F., 24 Park Place, New York, N. Y. (36).
- Allen, Walter S., 13 Beacon St., Boston, Mass. (39). C I
- Alwood, W. B., Agricultural and Mechanical College, Experiment Station, Blacksburg, Va. (39).
- Ammidown, Edward H., P. O. Box 2739, New York, N. Y. (37).
- Anderson, Alexander D., Washington, D. C. (38).
- Anderson, Newton M., 871 Sibley St., Cleveland, Ohio (30). B
- Andrews, Prof. Launcelot W., Iowa City, Iowa (39). C
- Angell, Geo. W. J., 44 Hudson St., New York, N. Y. (36).
- Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
- Appleton, Rev. Edw. W., D.D., Ashbourne, Montgomery Co., Pa. (28).
- Archambault, U. E., P. O. Box 1944, Montreal, P. Q., Can. (31).
- Ashley, Prof. William James, 29 Harbord St., Toronto, Ontario, Can. (38)
- Atkinson, George F., Auburn, Ala. (39). F
- Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
- Atwood, E. S., East Orange, N. J. (29). F
- Austin, Wm., Belvidere House, 4th Ave., cor. 18th St., New York, N. Y. (36).
- AVERY, SAMUEL P., 4 E. 38th St., New York, N. Y. (36).
- Ayer, Edward Everett, Room 12, The Rookery, Chicago, Ill. (37). H
- Bain, James, jr., Toronto, Ontario, Can. (38).
- Baker, Philip S., M.D., DePauw University, Greencastle, Ind. (39). C
- Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
- Baker, Wm. G., 284 E. 15th St., New York, N. Y. (36).
- Balderton, C. Canby, Westtown, Chester Co., Pa. (33). B
- Baldwin, Judge Charles C., 1264 Euclid Ave., Cleveland, Ohio (37). H I
- Baldwin, Miss Mary A., 28 Fulton St., Newark, N. J. (31). E
- Baldwin, Mrs. G. H., 8 Madison Ave., Detroit, Mich. (34). H
- Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). E F
- Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
- BANGS, LEMUEL BOLTON, M.D., 127 E. 34th St., New York, N. Y. (36).
- Barber, D. H., Marion, Iowa (37).
- Barclay, Robert, A.M., M.D., 3211 Lucas Ave., St. Louis, Mo. (20).
- Bardeen, Francis L., M.D., Box 76, Onondaga Hill, N. Y. (32). C F B
- BARGE, B. F., Mauch Chunk, Pa. (33).
- Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
- Barnum, Miss Charlotte C., 144 Humphrey St., New Haven, Conn. (36). A
- Bartley, Elias H., M.D., 21 Lafayette Ave., Brooklyn, N. Y. (33). C
- Bass, Wm. H., 393 College Ave., Indianapolis, Ind. (39). D
- Bastin, Edson Sewell, 8330 S. Park Ave., Chicago, Ill. (39).
- Bates, Prof. Clifton Owen, Cedar Rapids, Iowa (38).
- Bates, Wm. W., Com. of Navigation, Washington, D. C. (38).
- Batterson, J. G., Hartford, Conn. (28).

- Baxter, James N., 18 Fulton St., Brooklyn, N. Y. (36).
 Baxter, Sylvester, office of the Herald, Boston, Mass. (36). H
 Beach, William H., Madison, Wis. (21). E B
 Beale, Oscar J., care Brown & Sharpe, Providence, R. I. (39). D
 Bean, Thos. E., Laggan Station, Can. Pacific Railway, Alberta Terr., Can. (28). F
 Beardslee, H. C., 801 Wilson Ave., Cleveland, Ohio (37). F
 Beaver, Daniel B. D., M.D., 150 North 6th St., Reading, Pa. (39).
 Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
 Bill, C. M., M.D., 320 Fifth Ave., New York, N. Y. (36).
 Bell, Leonhard, 92 North East St., Indianapolis, Ind. (39).
 Benjamin, E. B., 6 Barclay St., New York, N. Y. (19). B C
 Bennett, Charles M., Logansport, Ind. (39).
 Benns, Chas. P., Schenectady, N. Y. (38). D
 Benton, George W., High School, Indianapolis, Ind. (39). C
 Beveridge, David, 145 Griswold St., Detroit, Mich. (38). I
 Bidle, James G., 924 Chestnut St., Philadelphia, Pa. (39).
 Blen, Julius, 139 Duane St., New York, N. Y. (34). E H
 Bigelow, Miss Clarissa, Kalamazoo, Mich. (39). A
 Bigelow, Otis, 605 7th St., Washington, D. C. (30). H F
 Bingham, Mrs. Martha A. (32).
 Birdsall, Miss Louise W., 105 E. 37th St., New York, N. Y. (37). F E
 Birge, Charles P., Keokuk, Iowa (29). E
 Bishop, HEBER R., Mills Building, New York, N. Y. (36).
 Bixby, Wm. H., Wilmington, N. C. (34). D
 Blackstock, Rev. W. S., 20 Homewood Ave., Toronto, Ont., Can. (38). E
 Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
 Blakslee, Prof. T. M., North Des Moines, Iowa (31). A
 Blatchford, Eliphilet W., 375 La Salle Ave., Chicago, Ill. (17). F
 Blatchley, Willis S., Terre Haute, Ind. (39). F
 Bleile, Albert M., M.D., 342 S. Fourth St., Columbus, Ohio (37) F
 Blish, W. G., Niles, Mich. (38). B D
 Blount, Henry F., University Park, Washington, D. C. (32). I B
 Blount, Mrs. Lucia E., Univ. Park, Washington, D. C. (34). H I
 Blue, Archibald, Ass't Minister of Agric., Toronto, Ontario, Can. (35). I
 Boardman, William Dorr, 88 Kenilworth St., Roxbury, Mass. (38). E
 Boiley, Henry L., North Dakota Agric. Coll., Fargo, North Dakota (39). F
 Bolton, Prof. John, 49 Huntington St., Cleveland, Ohio (37).
 Booraem, J. V. V., 204 Lincoln Place, Brooklyn, N. Y. (36).
 Booth, Miss Mary A., Longmeadow, Mass. (34). F I
 Booth, Samuel C., Longmeadow, Mass. (34). E I
 Bourland, Addison M., M.D., Van Buren, Ark. (20). C E F
 Boustead, W. E., Toronto, Ontario, Can. (38).
 Bowers, Miss Virginia K., 61 Taylor St., Newport, Ky. (27). F H B C
 Bowman, Chas. G., Lt. U. S. N., Naval Acad., Annapolis, Md. (38).
 Bowman, Walker, Blacksburg, Va. (39).
 Boyer, Jerome L., Superintendent Chestnut Hill Iron Ore Co., Reading, Pa. (35). D

- Brackett, Richard N., Chemist of the Geological Survey of Arkansas,
Little Rock, Ark. (37). **C E**
- Bradford, Chester, Patent Attorney, 16 & 18 Hubbard Block, Indianapolis,
Ind. (39). **D**
- Bradford, Royal B., Commander U. S. N., care of Navy Department,
Washington, D. C. (81). **B D**
- Braid, James W., Nashville, Tenn. (33).
- Brannon, M. A., Fort Wayne, Ind. (39). **F**
- Bray, Prof. C. D., College Hill, Mass. (29). **D B**
- Brayton, Miss Sarah H., M.D., Evanston, Ill. (38).
- Brice, Judge Albert G., 19 Camp St., New Orleans, La. (32). **H**
- Bristol, Wm. H., Stevens Institute, Hoboken, N. J. (36). **A B D**
- Bromfield, Rev. Edw. T., Glenbrook, Fairfield Co., Conn. (33). **F H**
- Brooke, Dr. Emma W., 15th and Chestnut Sts., Phila., Pa. (38). **C E**
- Brooks, Prof. Wm. P., Amherst, Mass. (38). **C F**
- Brown, Albert P., Ph.D., 501 Federal St., Camden, N. J. (33). **F C**
- Brown, Miss Anna M., 528 W. 7th St., Cincinnati, Ohio (31). **F**
- Brown, Prof. Charles Sumner, Rose Polytechnic Institute, Terre Haute,
Ind. (39). **D**
- Brown, Henry A., Saxonville, Mass. (38). **I**
- Brown, Rev. Henry M., East Aurora, Erie Co., N. Y. (35). **F C**
- Brown, Jonathan, 390 Broadway, Somerville, Mass. (29).
- Brown, Paul Taylor, 215 So. 41 St., Philadelphia, Pa. (33). **E**
- Brownell, Silas B., 71 Wall St., New York, N. Y. (36).
- Brownell, Prof. Walter A., 905 University Avenue, Syracuse, N. Y. (30)
E B C
- Bryce, Peter H., M.D., Toronto, Ontario, Can. (38).
- Buckingham, Chas. L., 195 Broadway, New York, N. Y. (28).
- Buffum, Miss Fannie A., Linden, Mass. (29). **E C**
- Bulloch, Walter H., 99 W. Monroe St., Chicago, Ill. (30). **F**
- Burke, William, U. S. Patent Office, Washington, D. C. (28).
- Burman, Rev. W. A., Winnipeg, Manitoba (38). **F H**
- Burns, Prof. James A., Box 206, Atlanta, Ga. (32). **C E I**
- Burr, Mrs. Laura E., Commercial Hotel, Lansing, Mich. (34). **B**
- Burwell, Arthur W., 208 Superior St., Cleveland, Ohio (37).
- Bush, Rev. Stephen, D.D., Waterford, N. Y. (19). **E H**
- Byrd, Mary E., Box 110, Lawrence, Kan. (34). **A**
- Cabot, John W., Bellaire Nail Works, Bellaire, Belmont Co., Ohio (35).
D
- Calder, Edwin E., 15 Board of Trade Building, Providence, R. I. (29). **C**
- Caldwell, Wm. H., State College, Centre Co., Pa. (37). **I F**
- Calkins, Dr. Marshall, Springfield, Mass. (29).
- Campbell, Jos. Addison, Queen Lane, Falls of Schuylkill P. O., Philadelphia, Pa. (38).
- Campbell, Prof. John L., Crawfordsville, Ind. (39). **B**
- Campbell, John T., Rockville, Ind. (39).
- Campbell, Wm. A., M.D., Ann Arbor, Mich. (34). **F B**

- Campbell, William Wallace, University of Michigan, Ann Arbor, Mich. (38). **A**
- Cannon, George L., jr., 1926 Pennsylvania Ave., Denver, Col. (39). **F H**
- Capen, Miss Bessie T., Northampton, Mass. (28). **C**
- Cardeza, John M., M.D., Clifmont, Del. (38). **E**
- Carman, Prof. A. P., La Fayette, Ind. (39). **B**
- Caron, C. K., Louisville, Ky. (30). **E C**
- Carpenter, Geo. O., jr., care of St. Louis Lead and Oil Co., St Louis, Mo. (29).
- Carrington, Col. Henry B., U. S. A., Hyde Park, Mass. (20).
- Carter, Calvin, C.E., Brookville, Ind. (37). **D**
- CARTER, JAMES C., 277 Lexington Ave., New York, N. Y. (36).
- Carter, James Madison G., M.D., Waukegan, Ill. (39). **F**
- Carter, John E., Knox and Coulter Sts., Germantown, Pa. (38). **B H**
- Cary, Albert A., 234 W. 29th St., New York, N. Y. (36). **D**
- Casey, Thomas L., Room 79, Army Building, 89 Whitehall St., New York, N. Y. (38). **F**
- Catlin, Charles A., 138 Hope St., Providence, R. I. (38). **C**
- Chadbourne, Erlon R., Lewiston, Me. (29).
- Chaffee, Prof. Arthur B., South Bend, Ind. (37)
- Champlin, John D., Jr., 745 Broadway, New York, N. Y. (36).
- Chandler, John R., Ph.D., U. S. Vice Consul General, Guatemala, Central America (36). **F H**
- Chaplin, Prof. Winfield S., Harvard Univ., Cambridge, Mass. (37). **D A**
- Charbonnier, Prof. L. H., University of Georgia, Athens, Ga. (26). **A B D**
- Chase, Rev. E. B., Lyons, Iowa (37).
- Chase, Mrs. Mariné J., 1710 Chestnut St., Philadelphia, Pa. (31). **E F**
- Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). **F**
- Chatfield, A. F., Albany, N. Y. (29).
- Chester, Commander Colby M., U. S. N., care Navy Dept., Washington, D. C. (28). **E**
- Childs, Win. Addison, M.A., National Club, Toronto, Ont., Can. (38). **C H D**
- Chipinan, J. W., Indianapolis, Ind. (39). **B**
- Christian, Ira W., Noblesville, Ind. (39).
- Christie, Alexander Smyth, Coast and Geodetic Survey, Washington, D. C. (39). **A B D**
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- Post, Prof. Charles M., Alfred Centre, N. Y. (39). **B**
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- Price, Eli Kirk, jr., 709 Walnut St., Philadelphia, Pa. (33). **I B**
- Price, J. Sergeant, 709 Walnut St., Philadelphia, Pa. (33).

MEMBERS.

- Prince, Gen. Henry, U. S. A., Fitchburg, Mass. (22).
 • Prosser, Charles S., B.S., National Museum, Washington, D. C. (83). E F
 Prosser, Col. Wm. F., North Yakima, Yakima Co., Washington (26). E I
 PRUYN, JOHN V. L., JR., Albany, N. Y. (29).
 Pulsifer, Mrs. C. L. B., 1837 Kennett Place, St. Louis, Mo. (83).
 Purinton, Prof. George D., Columbia, Mo. (81). C F
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 Quinn, James Cochrane, Ph.D., Helena, Montana (83). E F H I
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 Randall, J. F., The Hollenden, Cleveland, Ohio (87). D
 Randolph, L. S., Engineer of Tests, B. & O. R. R. Co., Baltimore, Md. (83). D
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 Read, Matthew C., Hudson, Ohio (86).
 Reber, Prof. Louis E., State College, Centre Co., Pa. (85). D
 Redding, Prof. Allen C., Findlay, Ohio (89). C
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 Reed, Taylor, Princeton, N. J. (88). A
 Reese, Charles L., 1801 Linden Ave., Baltimore, Md. (89). C
 Reese, Jacob, 400 Chestnut St., Philadelphia, Pa. (88). D B
 Reid, Prof. Henry F., Case School Applied Science, Cleveland, Ohio (86). B
 Remington, Cyrus K., 11 E. Seneca St., Buffalo, N. Y. (85). E
 Renninger, John S., M.D., Marshall, Minn. (31). C F
 Reyburn, Robert, M.D., 2129 F St., N. W., Washington, D. C. (88). F
 Reynolds, Henry Lee, Washington, D. C. (87).
 Reynolds, Sheldon, Wilkes Barre, Pa. (88). H
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 Richmond, Geo. B., Lansing, Mich. (84). C B
 Ricketts, Col. R. Bruce, Wilkes Barre, Pa. (88). H
 Rideout, Bates S., Norway, Me. (81). E H
 Ridpath, John Clark, Greencastle, Ind. (89). H
 Ries, Elias E., 430 South Broadway, Baltimore, Md. (88). B I
 Riggs, Geo. W., Ridgefield, Conn. (26). C
 Riggs, Lawrason, 814 Cathedral St., Baltimore, Md. (86).
 Ringueberg, Eugene N. S., M.D., Lockport, N. Y. (88). E F
 RIVERA, José de (29).
 Robbins, E. P., Room 12, Apollo Building, N. W. cor. Walnut and Fifth
 Sts., Cincinnati, Ohio (30). D B
 Roberts, Edward Chrismon, Abingdon, Washington Co., Va. (87). D B
 Roberts, Eugene H., Oxford, Miss. (38).
 Roberts, Prof. Milton Josiah, 105 Madison Ave., New York, N. Y. (88).
 B D H

- Robertson, Charles, Carlinville, Ill. (39). F
- Robertson, Col. D. A., Climatologist, 294 Laurel Ave., St. Paul, Minn. (32).
- ROBERTSON, THOMAS D., Rockford, Ill. (10). E H
- Robeson, Henry B., care Mills, Robeson & Smith, 84 Wall St., New York, N. Y. (29).
- Robinson, Prof. Otis Hall, 278 Alexander St., Rochester, N. Y. (23). B A
- Robinson, Prof. Thomas (38). B C A
- Rochester, DeLancey, M.D., 469 Franklin St., Buffalo, N. Y. (35). F
- Rockwood, Charles G., Newark, N. J. (36).
- Roessler, Franz, 78 Pine St., New York, N. Y. (39).
- Rogers, John, Port Sandfield, Muskoka, Ontario, Can. (38). D
- Rolfe, Charles W., Univ. of Illinois, Champaign, Ill. (32).
- Roosevelt, Hon. Robert B., Pres. Holland Trust Co., 7 Wall St., New York, N. Y. (33). B F
- ROOSEVELT, MRS. ROBERT B., Holland Trust Co., 7 Wall St., New York, N. Y. (31). H I
- Rosa, Edward Bennett, care Johns Hopkins Univ., Baltimore, Md. (39). A B
- Rosebrugh, A.M., M.D., Church Street, Toronto, Ontario, Can. (38).
- Ross, Denman Waldo, Ph.D., Cambridge, Mass. (29).
- Ross, James F. W., M.D., Sherborne and Wellesley Streets, Toronto, Ontario, Can. (38). H
- Roth, Fillibert, 58 So. Fifth St., Ann Arbor, Mich. (39). F
- Rowell, Chas. E., M.D., Stamford, Conn. (38). F H
- Runnels, Dr. O. S., Indianapolis, Ind. (39). F
- Rupp, August, A.B., New York College, New York, N. Y. (35).
- Russell, A. H., Captain of Ordnance, U. S. A., 84 Huntington Ave., Boston, Mass. (38). D
- Russell, Dr. Linus E., Springfield, Ohio (30).
- Russell, Thomas, Signal Office, Washington, D. C. (39). B
- Rust, Horatio N., Colton, San Bernardino Co., Cal. (26). H
- Ryerson, George S., 60 College Ave., Toronto, Ontario, Can. (38). F
- Sabine, Wallace Clement, Harvard College, Cambridge, Mass. (39). B
- Sackett, Miss Eliza D., Cranford, N. J. (35). F H
- Saegmuller, G. N., 182 Maryland Ave., S. W., Washington, D. C. (38). A B
- Safford, Charles W., Rutland, Vt. (26). D C
- Sage, John H., Portland, Conn. (23). F
- Sander, Dr. Enno, St. Louis, Mo. (27). C
- Sargent, Erle Hoxsie, Orchard Lake, Michigan (37). F
- Satterlee, Samuel K., Rye, West Chester Co., N. Y. (36).
- Saville, James H., Attorney-at-Law, 1419 F St., N. W., Washington, D. C. (29).
- Saville, Marshall H., Peabody Museum, Cambridge, Mass. (39). H
- Sawyers, Mrs. Alice M. S., 1019 Burnett St., Fort Worth, Texas (34).
- Sayre, Robert H., Bethlehem, Pa. (28). D

- SCHAFFER, CHAS., M.D., 1309 Arch St., Philadelphia, Pa. (29). **F E**
- SCHAFFER, MRS. MARY TOWNSKND SHARPLESS, 1309 Arch St., Philadelphia, Pa. (38). **F E**
- Scharar, Christian H., 2078 N. Main Ave., Scranton, Pa. (38). **A D E H**
- SCHERMERHORN, F. AUG., 61 University Place, New York, N. Y. (36).
- SCHERMERHORN, WM. C., 49 W. 23d St., New York, N. Y. (36).
- Scherzer, William, 510 Home Insurance Building, Chicago, Ill. (39).
- Schobinger, John J., 2101 Indiana Ave., Chicago, Ill. (34). **B**
- Schofield, Gen. J. M., Headquarters of the Army, Washington, D. C. (36).
- Schöney, Dr. L., 68 East 104th St., New York, N. Y. (29). **F**
- Schou, A. H., 677 25th St., Oakland, Cal. (35).
- Schrenk, Prof. Joseph, Hoboken, N. J. (36).
- Schuette, J. H., Green Bay, Wis. (34). **F E B**
- Schultz, Carl H., 430-440 First Ave., New York, N. Y. (29).
- Schuylar, Phillip N., Bellevue, Huron Co., Ohio (37).
- Schwarz, E. A., U. S. Dep't of Agric., Washington, D. C. (29). **F**
- Scott, Charles F., Westinghouse Electric Co., Pittsburgh, Pa. (34). **B A**
- Scott, John B., 1520 Arch St., Philadelphia, Pa. (38). **C**
- Scott, Martin P., M.D., Prof. of Agric. and Natural History, Blacksburg, Va. (31).
- Scott, W. J., M.D., 537 Prospect St., Cleveland, Ohio (37).
- Scoville, S. S., M.D., Lebanon, Ohio (30). **E F**
- Scupham, John R., 946 Myrtle St., Oakland, Cal. (38). **E**
- Seamon, Prof. William H., Eng., Aurora, Mo. (38).
- Searle, Prof. George M., Catholic Univ., Washington, D. C. (39). **A**
- Selwyn, Alfred R. C., Director Geol. Survey of Canada, Ottawa, Ontario, Can. (38). **E**
- Sennett, George B., Am. Mus. Nat. History, Central Park (77th St. and 8th Ave.), New York, N. Y. (31).
- Serrell, Lemuel W., 140 Nassau St., New York, N. Y. (36).
- Sessions, Francis C., Columbus, Ohio (34).
- Shaler, Prof. Nathaniel S., Harvard Univ., Cambridge, Mass. (37). **E**
- Shannon, W. P., Greensburg, Ind. (39). **F**
- SHEAVER, A. W., Pottsville, Pa. (28).
- Sheafer, Walter S., Pottsville, Pa. (25).
- Shelton, Prof. Edward M., Dep't of Agric., Brisbane, Queensland, Australia (32). **F**
- Shepard, William A., Saratoga Springs, N. Y. (28).
- Shepherd, Elizabeth, 253 W. 128th St., New York, N. Y. (39).
- Sherman, Prof. F. A., Hanover, N. H. (29). **A B**
- Sherman, Orray Taft, 379 Harvard St., Cambridge, Mass. (39).
- Shonnard, Hon. Frederic, Yonkers, N. Y. (39). **E F H**
- Shultz, Charles S., Hoboken, N. J. (31). **F**
- Shuttleworth, Edward B., Toronto, Ontario, Can. (38). **C**
- Siebel, John E., Director Zymotechnic Inst., 242 Burling St., Chicago, Ill. (39). **C B F E**
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 Smith, Benj. G., Cambridge, Mass. (29). I
 Smith, Charles H., Drawer 19, Austin, Texas (38). D
 Smith, De Cost, Skaneateles, N. Y. (38). H
 Smith, D. T., M.D., Louisville, Ky. (89).
 Smith, E. Reuel, Skaneateles, N. Y. (88).
 Smith, Prof. Edgar F., Univ. of Penna., Philadelphia, Pa. (38). C
 Smith, Geo. Gregory, St. Albans, Vt. (86).
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 Smith, Mrs. Henry L., 149 Broadway, New York, N. Y. (26).
 Smith, Prof. Herbert S. S., Coll. of New Jersey, Princeton, N. J. (29).
 D
 Smith, Mrs. J. Lawrence, Louisville, Ky. (26).
 Smith, Jas. Perrin (37). C E
 Smith, Miss Jennie, Peabody Museum, Cambridge, Mass. (29). H
 Smith, Robert D., Pres. Columbia Athenæum, Columbia, Tenn. (39).
 Smith, Prof. Thomas A., Beloit, Wis. (38). B A
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 Smyth, C. H., Jr., Clinton, N. Y. (38).
 Smyth, Prof. Jas. D., Burlington, Iowa (28). I
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 Souvielle, Mrs. M., Box 385, Jacksonville, Fla. (24). A B F
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 SPRAGUE, C. H., Malden, Mass. (29).
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 Stam, Colin F., Chestertown, Md. (33). C F

- Wadsworth, H. L., 1209 17th St., Denver, Col. (39). **D**
Wagner, Frank C., care Wm. Wagner, Ann Arbor, Mich. (34). **D**
Walte, M. B., Dep't of Agriculture, Washington, D. C. (37).
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Washington, D. C. (38). **B D**
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Wardwell, George J., Rutland, Vt. (20). **D E**
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Waring, John, Manchester, Conn. (38). **D B**
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Ill. (34). **D A B**
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Watson, Miss C. A., Salem, Mass. (31). **D**
Weaver, Gerritt E. Hambleton, A.M., Swarthmore College, Swarthmore,
Pa. (38). **F**
Weed, J. N., Newburgh, N. Y. (87). **E I**
Weeden, Hon. Joseph E., Randolph, Cattaraugus Co., N. Y. (31).
Weeks, Joseph D., Editor American Manufacturer, Pittsburgh, Pa. (35).
D
Welch, Thomas V., Superintendent State Reservation, Niagara Falls, N.Y.
(35).
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Wheeler, Arthur S., Tulane Univ., New Orleans, La. (36).
Wheeler, Herbert A., Washington Univ., St. Louis, Mo. (33). **E I**

- Wheeler, Moses D., M.E., P. O. Box 539, Stapleton, Staten Island, N. Y.
(85). **D**
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- Wheildon, Miss Alice W., Concord, Mass. (31).
- Whelen, Edw. S., 1520 Walnut St., Philadelphia, Pa. (33).
- Whetstone, John L., Summit Ave., Mt. Auburn, Cincinnati, Ohio (30). **D**
- White, Charles H., Med. Inspector U.S.N, care A. B. Gilman, Bradford,
Mass. (34). **C**
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- White, LeRoy S., Box 324, Waterbury, Conn. (23).
- White, Loomis L., 7 E. 44th St., New York, N. Y. (36).
- White, Z. L., Washington, D. C. (37). **I**
- Whiting, S. B., 24 Highland Ave., Cambridgeport, Mass. (33). **D**
- Whitlock, Prof. Roger H., Coll. Station, Brazos Co., Texas (36). **A B D**
- Wickersham, Jas. A., Rose Polytechnic Inst., Terre Haute, Ind. (39). **H**
- Wilbor, Rev. W. C., Ph.D., 492 W. Ferry St., Buffalo, N. Y. (39). **F**
- Wilbour, Mrs. Charlotte B., Little Compton, R. I. (28).
- Wilcox, Miss Emily T., 85 Second St., Troy, N. Y. (33). **B A**
- Wilder, Alex., M.D., 565 Orange St., Newark, N. J. (29). **H F I**
- Wilkinson, J. Henderson, 320 E. Capitol St., Washington, D. C. (35). **E**
- Wilkinson, Mrs. L. V., Seventy Six P. O., Perry Co., Mo. (30).
- Willets, Joseph C., Skaneateles, N. Y. (29). **E F H**
- Willits, George E., Lansing, Mich. (39). **F**
- Williams, C. T., 871 Case Ave., Cleveland, Ohio (37).
- Williams, Prof. Edward H., jr., Box 463, Bethlehem, Pa. (25). **E D**
- Willmott, Arthur B., Antioch College, Yellow Springs, Ohio (38).
- Wilmot, Thos. J., Commercial Cable Co., Waterville, County Kerry, Ire-
land (27). **B**
- Winchell, Martin R., 120 Nassau St., New York, N. Y. (36). **I**
- Windle, Prof. W. S., Richmond, Ind. (39). **F**
- Wingate, Miss Hannah S., 12 W. 125th St., New York, N. Y. (31). **E I**
- Winterhalter, A. G., Lt. U. S. N., U. S. Naval Observ., Washington, D.C.
(37) **A**
- Wisser, John P., 1st Lt., 1st Artillery, U. S. A., West Point, N. Y. (33). **C**
- Withers, Prof. W. A., Agric. Mechanical College, Raleigh, N. C. (38). **C**
- Witt, Carl C., Indianapolis, Ind. (39).
- Witton, James G., B.A., University Coll., Toronto, Ontario, Can. (38). **B**
- Wolcott, Mrs. Henrietta L. T., Dedham, Mass. (29).
- Wolf, Theo. R., Ph.D., Newark, Delaware (36).
- Wolff, Dr. J. E., 15 Story St., Cambridge, Mass. (36).
- Wood, Alvinus B., 980 Jefferson Ave., Detroit, Mich. (34). **E**
- Wood, Joseph S., Mount Vernon, Westchester Co., N. Y. (36).
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- Wood, DR. ROBERT W., Jamaica Plain, Mass. (29).
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- Wood, Dr. William B., 22 E. 41st St., New York, N. Y. (36).

- Woodward, A. E., Jefferson City, Mo. (39). **H**
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N. Y. (36). **B D**
Wright, Rufus, 388-389 Lake St., Chicago, Ill. (87). **B**
Würtele, Miss Minnie, Acton Vale, P. Q., Can. (32). **H**
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Youmans, Mrs. Celia G., Mount Vernon, N. Y. (36).
Young, Prof. A. Harvey, Hanover College, Hanover, Ind. (80). **F C**
Young, Archibald Hope, Upper Canada College, Toronto, Ontario, Can.
(38).

Zalinski, E. L., Cap't 5th Art'y, U. S. A., Fort Hamilton, New York Har-
bor, N. Y. (36).

[1188 PATRONS AND MEMBERS.]

NOTE.—The omission of an address in the foregoing list indicates that letters directed to that last printed were returned as uncalled for. Information of the present address of the members so indicated is requested by the PERMANENT SECRETARY.

HONORARY FELLOWS.¹

- ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Born Dec. 7, 1804. Died May 30, 1882.) **B E**
 CHEVREUL, MICHEL EUGÈNE, Paris, France (85). 1886. (Born Aug. 31, 1786. Died April 9, 1889.) **C**
 GENTH, DR. F. A., 8937 Locust St., Philadelphia, Pa. (24). 1888.
C E
 HALL, PROF. JAMES, Albany, N. Y. (1). 1890. **E F**

F E L L O W S.²

- Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16).
 1874. **B A**
 Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**
 Adams, Frank Dawson, McGill Coll., Montreal, P. Q., Can. (29). 1885.
 Alden, Prof. Geo. I., Worcester, Mass. (83). 1885. **D**
 Alexander, John S., Texas Nat'l Bank, San Antonio, Texas (20). 1874.
B C D
 Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. **F**
 Allen, Joel A., American Museum of Natural History, Central Park,
 New York (18). 1875. **F**
 Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (85). 1887. **F**
 Alvord, Major Henry E., College Park, Prince George's Co., Md. (29).
 1882. **I**
 Ammen, Daniel, Rear Admiral U. S. Navy, Ammendale, Prince George's
 Co., Md. (26). 1881. **E**
 Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. **H**
 Anthony, Prof. Wm. A., Manchester, Conn. (28). 1880. **B**
 Antisell, Thomas, M.D., 1811 Q St., N. W., Washington, D. C. (83). 1890.
C E
 Arey, Albert L., Free Academy, Rochester, N. Y. (35).
 Arthur, J. C., La Fayette, Ind. (21). 1883. **F**
 Atkinson, Edward, 81 Milk St., Boston, Mass. (29). 1881. **I D**
 Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. **C**
 Atwell, Charles B., 461 Emerson St., Evanston, Ill. (86). 1890. **F**
 Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. **D A**
 Avery, Elroy M., Ph.D., Woodland Hills Ave., Cleveland, Ohio (37).
 1889. **B**
 Ayers, Howard (84). 1886. **F**

¹ See ARTICLE VI of the Constitution. ² See ARTICLE IV of the Constitution.

. The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the Fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

- Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). 1887. **H I**
- Babcock, S. Moulton, Madison, Wis. (33). 1885. **C**
- Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). 1889. **C E**
- Bailey, Prof. Liberty H., Ithaca, N. Y. (34). 1887. **F**
- Bailey, Prof. Loring W., University of Fredericton, N. B. (18). 1875.
- Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874.
F
- Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (81). 1886.
F H
- Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30).
1882. **A**
- BARKER, PROF. G. F., Univ. of Penn., Philadelphia, Pa. (18). 1875. **B C**
- Barnard, Edward E., Lick Observ., San José, Cal. (26). 1883. **A**
- Barnes, Prof. Chas. R., Madison, Wis. (33). 1885. **F**
- Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28).
1883. **C**
- Bartlett, John R., Commander U. S. N., Lonsdale, R. I. (30). 1882. **E B**
- Barus, Carl, Ph.D., U. S. Geol. Survey, Washington, D. C. (33). 1887. **B**
- Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**
- Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B
D I**
- Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887.
B A C D
- Battle, Herbert B., Ph.D., Director N. C. Agric. Exper. Station, Raleigh,
N. C. (33). 1889. **C**
- Baur, George, New Haven, Conn. (36). 1889.
- Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**
- Baylor, James B., U. S. Coast and Geodetic Survey Office, Washington,
D. C. (33). 1888. **A**
- Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24).
1880. **F**
- Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa.
(33). 1885. **D**
- Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**
- Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). 1890.
E
- Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington,
D. C. (26). 1879. **B H I**
- Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**
- Bell, Robert, M.D., Ass't Director Geological Survey, Ottawa, Ontario,
Can. (38). 1889. **E F**
- Beman, Wooster W., 19 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**
- Benjamin, Marcus, 15 W. 121st St., New York, N. Y. (27). 1887. **C**
- Benjamin, Rev. Raphael, M.A., 178 E. 70th St., New York, N. Y. (34).
1887. **F A B D E H I**
- Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). 1889. **C**
- Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**

- Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18).
1875. **F**
- Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington,
D. C. (31). 1884. **F**
- Bickmore, Prof. Albert S., American Museum of Natural History, 8th
Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**
- Bigelow, Prof. Frank H., Naut. Almanac, Washington, D. C. (36). 1888. **A**
- Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington,
D. C. (32). 1883. **F H**
- Blackham, George E., M.D., Dunkirk, N. Y. (25). 1888. **F**
- Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24).
1877. **B F**
- Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. **B**
- Blake, Francis, Auburndale, Mass. (28). 1874. **B A**
- Boardman, Mrs. William D., 38 Keulworth St., Roxbury, Mass. (28).
1885. **E H**
- Boas, Dr. Franz, 196 Third Ave., New York, N. Y. (36). 1888. **H**
- Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. **A B E**
- BOLTON, DR. H. CARRINGTON, University Club, New York, N. Y. (17).
1875. **C**
- Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33).
1885. **D**
- Bourke, John G., Capt. 3d Cavalry, U. S. A., War Dept., Washington,
D. C. (33). 1885. **H**
- Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**
- Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**
- Bowditch, Henry L., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**
- Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.
- Brace, DeWitt B., Lincoln, Neb. (35). 1887. **B**
- Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**
- Branner, John C., Director of the Geological Survey of Arkansas, Little
Rock, Ark. (34). 1886. **E F**
- Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Wash-
ington, D. C. (36). 1888. **H I**
- Brashear, Jno. A., Allegheny, Pa. (33). 1885. **A B D**
- Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. **E F I**
- Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**
- Brinton, D. G., M.D., 2014 Chestnut St., Philadelphia, Pa. (33). 1885. **H**
- Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**
- Broadhead, Garland Carr, University, Columbia, Mo. (27). 1879. **E**
- Brooks, Wm. R., Box 714, Geneva, N. Y. (35). 1886. **A B D G**
- Brown, Robert, care of Yale College Observatory, New Haven, Conn.
(11). 1874.
- Brown, Mrs. Robert, New Haven, Conn. (17). 1874.
- Briihl, Gustav, cor. John and Hopkins Sta., Cincinnati, Ohio (28). 1886. **H**
- Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. **B**
- BRUSH, PROF. GEORGE J., Yale College, New Haven, Conn. (4). 1874. **C E**

- Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (88). 1889.
H
- Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**
- Burgess, Dr. Thomas J. W., Med. Sup't, Protestant Hospital for the Insane, Montreal, P.Q., Can. (88). 1889. **F**
- Burr, Prof. William H., Phoenixville, Chester Co., Pa. (81). 1888.
- Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**
- Butler, A. W., Brookville, Franklin Co., Ind. (80). 1885. **F H**
- Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**
- Calvin, Prof. Samuel, State Univ. of Iowa, Iowa City, Iowa (37). 1889.
E F
- Campbell, Douglas H., Ind. Univ., Bloomington, Ind. (34). 1888. **F**
- Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**
- Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29). 1881. **B**
- Carpenter, Louis G., Agricultural College, Fort Collins, Col. (32). 1889.
A B
- Carpenter, Capt. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
- Carpmael, Charles, Director of Magnetic Observatory, Toronto, Ontario, Can. (81). 1883. **B**
- Carr, Lucien, Peabody Museum Archaeology and Ethnology, Cambridge, Mass. (25). 1877. **H**
- Case, Col. Theo. S., Kansas City, Mo. (27). 1888. **H B**
- Chamberlain, Alexander F., Clark Univ., Worcester, Mass. (38). 1890. **H**
- Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**
- Chandler, Prof. C. F., School of Mines, Columbia Coll., East 49th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
- Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
- Chandler, Seth C., jr., 16 Craigie St., Cambridge, Mass. (29). 1882. **A**
- Chanute, O., 5 Ritchie Place, Chicago, Ill. (17). 1877. **D I**
- Chapin, Dr. J. H., Meriden, Conn. (38). 1886. **E H**
- Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
- Chester, Prof. Fred'k D., Del. State Coll., Newark, Del. (33). 1887. **E**
- Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
- Chute, Horatio N., Ann Arbor, Mich. (84). 1889. **B C A**
- Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
- Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
- Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
- Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
- Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
- Clayton, H. Helm, Readville, Mass. (34). 1887. **B**
- Cloud, John W., 974 Rookery, Chicago, Ill. (28). 1886. **A B D**

- Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**
 Collett, Prof. John, Indianapolis, Ind. (17). 1874. **E**
 Collingwood, Francis, Elizabeth, N. J. (86). 1888. **D**
 Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y.
 (28). 1880. **E**
 Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison,
 Wis. (34). 1887. **A**
 Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**
 Comstock, Milton L., Knox College, Galesburg, Ill. (21). 1874. **A**
 Comstock, Prof. Theo. B., Geol. Survey of Texas, Austin, Texas. (24).
 1877. **D E B**
 Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**
 Cook, Chas. Sumner, Evanston, Ill. (36). 1889. **B**
 Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880.
B C
 Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33).
 1885. **D**
 Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**
 Cortell, Elmer L., 205 La Salle St., Chicago, Ill. (34). 1886. **D**
 Coulter, Prof. John M., Wabash College, Crawfordsville, Ind. (32). 1884. **F**
 Cox, Prof. Edward T., 18 Cortlandt St., New York, N. Y. (19). 1874. **E**
 Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30).
 1881. **F**
 Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**
 Cragin, Francis W., Washburn College, Topeka, Kan. (29). 1890. **F E H**
 Crampton, Chas. A., M.D., Office of Internal Revenue, Treasury Depart-
 ment, Washington, D.C. (36). 1887. **C**
 Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**
 Crawford, Prof. Morris B., Middletown, Conn. (30). 1889. **B**
 Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass.
 (29). 1881. **E**
 Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29).
 1880. **B**
 Culin, Stewart, 127 South Front St., Philadelphia, Pa. (33). 1890. **H**
 Cummings, John, Cummingsville, Woburn, Mass. (18). 1890. **F**
 Cushing, Henry Platt, 786 Prospect St., Cleveland, Ohio (33). 1888. **E**
 Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

 Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. **F H**
 Dall, William H., Smithsonian Institution, Washington, D. C. (18).
 1874. **H F**
 Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**
 Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**
 Dancy, Frank B., A.B., Analytical and Consulting Chemist, Office and Lab-
 oratory, 133½ Fayetteville St., Raleigh, N. C. (33). 1890. **C**
 Davidson, Prof. Geo., U. S. Coast and Geodetic Survey, San Francisco,
 Cal. (29). 1881. **A B D**

- Davis, Wm. Morris, Cambridge, Mass. (38). 1885. **E B**
- Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**
- Day, David F., Buffalo, N. Y. (35). 1887. **F**
- Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**
- Denton, Prof. James E., Stevens Institute, Hoboken, N. J. (36). 1888. **D B A**
- Derby, Orville A., Rio Janeiro, Brazil, S. A. (39). 1890.
- Dewey, Fred P., Ph.B., 621 F St. N. W., Washington, D. C. (30). 1886. **C E**
- Dimmock, George, P. O. Box 15, Canobie Lake, N. H. (22). 1874. **F**
- Dodge, Charles R., 1336 Vermont Ave., Washington, D. C. (22). 1874.
- Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**
- Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**
- Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**
- Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. **A**
- Dorsey, Rev. J. Owen, Box 78, Tacoma Park, P. O., D. C. (31). 1888. **H**
- Douglass, Andrew E., 68 Pine St., New York, N. Y. (31). 1885. **H**
- Dow, Capt. John M., 88 W. 71st St., New York, N. Y. (31). 1884. **F H**
- DRAPER, DAN'L, Ph.D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**
- Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**
- DU BOIS, PROF. AUG. J., New Haven, Conn. (30). 1882. **A B D**
- Du Bois, Patterson, Ass't Editor S.S.T., 1081 Walnut St., Philadelphia, Pa. (38). 1887. **H C I**
- Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**
- Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.
- DUDLEY, WM. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. **C**
- Dudley, Prof. Wm. R., Cornell Univ., Ithaca, N. Y. (29). 1888. **F**
- Dunham, Edw. K., 53 E. 80th St., New York, N. Y. (30). 1890.
- Dunnington, Prof. F. P., University Station, Charlottesville, Va. (26). 1880. **C**
- Durand, Prof. W. F., Ph.D., Agricultural College, Mich. (37). 1890. **B**
- Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**
- Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**
- Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**
- Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**
- Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**
- Edison, Thos. A., Orange, N. J. (27). 1878. **B**
- Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

- Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y.
(27). 1879. C D E
- Elmbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874.
A B D
- Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. A
- Ely, Theo. N., Sup't Motive Power, Penn. R. R., Altoona, Pa. (29). 1886.
- Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. E F
- Emery, Albert H., Stamford, Conn. (29). 1884. D B
- Emery, Charles E., 22 Cortlandt St., New York, N. Y. (84). 1886. D B A
- EMMONS, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. E
- Engelmann, George J., M.D., 8003 Locust St., St. Louis, Mo. (25).
1875. F H
- Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. A
- Ewing, Thomas, jr., Patent Office, Washington, D. C. (36). 1889. B
- Eyerman, John, Easton, Pa. (33). 1889. E C
- Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. B D A
- Fairchild, Prof. H. L., University of Rochester, Rochester, N. Y. (28).
1883. E F
- Fall, Prof. Delos, Albion College, Albion, Mich. (84). 1887. C
- Fanning, John T., Consulting Eng., Great Northern Railway Building,
St. Paul, Minn. (29). 1885. D
- Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. F
- Farmer, Moses G., Eliot, Me. (9). 1875.
- Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. A I
F B
- Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. F E
- Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. B
A
- Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture,
Washington, D. C. (31). 1887. F I
- Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. A B
- Firmstone, F., Easton, Pa. (33). 1887. D
- Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. I E
- Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29).
1883. H
- Fletcher, James, Dominion Entomologist, Ottawa, Ontario, Can. (31).
1888. F
- Fletcher, Dr. Robert, Army Medical Museum, Washington, D. C. (29).
1881. F H
- Flint, Albert S., Washburn Observ., Madison, Wis. (80). 1887. A
- Flint, James M., Surgeon U. S. N., Smithsonian Institution, Washington,
D. C. (28). 1882. F
- Foote, Dr. A. E., 4116 Elm Ave., Philadelphia, Pa. (21). 1874. E C
- Forbes, Prof. S. A., Univ. of Illinois, Champaign, Ill. (27). 1879. F
- Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. C B
- FRAZER, DR. PERSIFOR, Drexel Building, Room 1042, Philadelphia, Pa. (24).
1879. E C

- Frazier, Prof. B. W., The Lehigh University, Bethlehem, Pa. (24). 1882.
E C
- Frear, Wm., State College, Centre Co., Pa. (33). 1886. **C**
- French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. **B**
- Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**
- Frost, Edwin Brant, Hanover, N. H. (38). 1890. **A B**
- Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**
- Fulton, Prof. Robert B., University, Miss. (21). 1887. **B A**
- Gaffield, Thomas, 54 Allen St., Boston, Mass. (29). 1889. **C B**
- Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**
- Galbraith, Prof. John, Toronto, Ontario, Can. (38). 1889.
- Galloway, B. T., Dep't of Agriculture, Washington, D. C. (37). 1890. **F**
- Gannett, Henry, U. S. Geological Survey, Washington, D. C. (38). 1884.
E I A
- Gardiner, Dr. Edward G., Massachusetts Institute Technology, Boston, Mass. (29). 1890. **F**
- Gardiner, James T., 21 Elk St., Albany, N. Y. (25). 1879. **E**
- Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877. **B**
- Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. **F E**
- Gatschet, Dr. Albert S., Box 338, Washington, D. C. (30). 1882. **H**
- Gibbs, Prof. J. Willard, New Haven, Conn. (38). 1885. **B**
- Gilbert, G. K., U. S. Geological Survey, Washington, D. C. (18). 1874. **E**
- Gillman, Henry, U. S. Consul, Jerusalem, Palestine, via England and Brindisi (24). 1875. **H F**
- Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. **E H**
- Goessman, Prof. C. A., Mass. Agricultural College, Amherst, Mass. (18). 1875. **C**
- Goff, E. S., Madison, Wis. (35). 1889.
- Gold, Theodore S., West Cornwall, Conn. (4). 1887. **B C**
- Goldschmidt, S. A., Ph.D., 21 Jay St., Brooklyn, N. Y. (24). 1880. **C E B**
- Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. **C**
- Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
- Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
- Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. **A H**
- Gould, Dr. B. A., Cambridge, Mass. (2). 1875. **A B**
- Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. **A**
- Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884.
C E F
- Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. **B**
- Gray, Prof. Thomas, Terre Haute, Ind. (38). 1889.
- Green, Arthur L., La Fayette, Ind. (33). 1888. **C**
- Green, Traill, M.D., Easton, Pa. (1). 1874. **C F**

- Grimes, J. Stanley (17). 1874. **E H**
 Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. **F E**
 Gulley, Prof. Frank A., College Station, Texas (30). 1883.
- Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass.
 (17). 1875. **F**
 Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
 Haines, Reuben, Haines and Chew St., Germantown, Philadelphia, Pa.
 (27). 1889. **C B**
 Hale, Albert C., Ph.D., No. 551 Putnam Ave., Brooklyn, N. Y. (29). 1886.
C B
 Hale, Horatio, Clinton, Ontario, Can. (30). 1882. **H**
 Hall, Prof. Asaph, U. S. Naval Observatory, Washington, D. C. (25).
 1877. **A**
 Hall, Asaph, Jr., U. S. Naval Observatory, Washington, D. C. (38). 1890.
A
 Hall, Prof. C. W., 803 Univ. Ave. So., Minneapolis, Minn. (28). 1888. **E**
 Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. **B**
 Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. **C**
 Hallowell, Miss Susan M., Wellesley Coll., Wellesley, Mass. (38). 1890. **F**
 Halsted, Byron D., New Jersey Agricultural Experiment Station, New
 Brunswick, N. J. (29). 1883. **F**
 Hanaman, C. E., Troy, N. Y. (19). 1888. **F**
 Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. **A**
 Harkness, Prof. William, U. S. N. Observatory, Washington, D. C.
 (26). 1878. **A B C D**
 Harrington, H. H., College Station, Texas (35). 1889. **C**
 Harris, Uriah R., Lieutenant U. S. N., U. S. S. Ranger, care of Navy Pay
 Office, San Francisco, Cal. (34). 1886. **A**
 Harris, W. T., Lock Box 1, Concord, Mass. (27). 1887. **H I**
 Hart, Edw., Ph.D., Easton, Pa. (38). 1885. **C**
 Hasbronck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (28). 1874. **D**
A I
 Hastings, C. S., Sheffield Scientific School of Yale College, New Haven,
 Conn. (25). 1878. **B**
 Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa.
 (32). 1885. **I D E**
 Haworth, Prof. Erasmus, Pennsylvania College, Oskaloosa, Iowa (37).
 1890. **E**
 Hay, Prof. O. P., Irvington, Ind. (37). 1889. **E F**
 Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. **H**
 Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885.
E F
 Heltzmann, Dr. Charles, 39 W. 45th St., New York, N. Y. (36). 1890.
 Hendricks, J. E., Des Moines, Iowa (29). 1885. **A**
 Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24).
 1877. **H**

- Hering, Rudolph, Civil and Sanitary Engineer, 277 Pearl St., New York, N. Y. (33). 1885. **D E I**
- Herrick, Clarence L., 12 Mason St., Mt. Auburn, Cincinnati, Ohio (31). 1884. **F E**
- Hervey, Rev. A. B., President St. Lawrence University, Canton, N.Y. (22). 1879. **F**
- Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. **E F**
- Hillgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**
- Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. **A I**
- Hill, Robert Thomas, Univ. of Texas, Austin, Texas (36). 1889. **E**
- Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**
- Hirschfelder, Chas. A., Vice Consul U. S. A., Toronto, Ontario, Can. (33). 1887. **H**
- HITCHCOCK, PROF. CHARLES H., Hanover, N. H. (11). 1874. **E**
- Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**
- Hobbs, A. C., Bridgeport, Conn. (28). 1886. **D**
- Hoffmann, Dr. Fred., "Rundschau," P. O. Box 1680, New York, N. Y. (28). 1881. **C F**
- Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. **A**
- Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. **B**
- Holmes, Prof. Jos. A., Chapel Hill, N. C. (33). 1887. **E F**
- Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**
- Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**
- Holway, E. W. D., Decorah, Iowa (33). 1890. **F**
- Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**
- Horton, S. Dana, Pomeroy, Ohio (37). 1889. **I**
- Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883. **B H**
- Hotchkiss, Major Jed., Staunton, Va. (31). 1888. **E H I**
- Hough, Prof. G. W., Director Dearborn Observatory, Evanston, Ill. (15). 1874. **A**
- Hough, Walter, U. S. National Museum, Washington, D. C. (38). 1890.
- Hovey, Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. **E H**
- Howard, Leland O., Dep't of Agric., Washington, D. C. (37). 1889. **F**
- Howe, Jas. Lewis, Louisville, Ky. (36). 1888. **C**
- Hoy, Philo R., M.D., 902 Main St., Racine, Wis. (17). 1875. **F H**
- Hulst, Rev. Geo. D., 15 Hinrod St., Brooklyn, N. Y. (29). 1887. **F**
- Hunt, George, 119 Prospect St., Providence, R. I. (9). 1874.
- Hunt, Dr. T. Sterry, Park Avenue Hotel, New York, N. Y. (1). 1874. **C E**
- Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**
- Hyde, Prof. E. W., Station D, Cincinnati, Ohio (25). 1881. **A**
- Iddings, Joseph P., U. S. Geological Survey, Washington, D. C. (31). 1884. **E**

- Jack, John G., Jamaica Plain, Mass. (31). 1890. **F**
 Jackson, Robert T., 83 Gloucester St., Boston, Mass. (87). 1890. **F**
 Jacobus, David S., Stevens Institute, Hoboken, N. J. (36). 1889. **D B A**
 James, Jos. F., M.S., U. S. Geol. Survey, Washington, D. C. (30). 1882.
F E
 Jastrow, Dr. Jos., Univ. of Wisconsin, Madison, Wis. (35). 1887. **H F**
 Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**
 Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**
 Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**
 Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**
 Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**
 Jewell, Theo. F., Commander U. S. Navy, Naval Torpedo Station and War
 College, Newport, R. I. (25). 1882. **B**
 Jillson, Dr. B. C., 6224 Station St., E.E., Pittsburgh, Pa. (14). 1881.
E H F
 Johnson, John B., Washington Univ., St. Louis, Mo. (38). 1886. **D**
 Johnson, Lawrence C., U. S. Geol. Survey, Gainesville, Fla. (38). 1887.
 Johnson, Otis C., 52 Thayer St., Ann Arbor, Mich. (34). 1886. **C**
 Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**
 Jordan, Prof. David S., Pres. Indiana Univ., Bloomington, Ind. (31).
 1883. **F**
 Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.
 Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875.
E C
 Kedzie, Mrs. Nellie S., Manhattan, Kan. (34). 1890. **I F**
 Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**
 Kelser, Edward H., Ph.D., Prof. of Chemistry, Bryn Mawr College, Bryn
 Mawr, Montgomery Co., Pa. (35). 1888. **C**
 Kellicott, David S., Columbus, Ohio (31). 1883. **F**
 Kemp, James F., Cornell Univ., Ithaca, N. Y. (36). 1888. **E**
 Kendall, Prof. E. Otis, 3826 Locust St., Philadelphia, Pa. (29). 1882. **A**
 Kent, William, Passaic, N. J. (26). 1881. **D I**
 Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**
 Keyes, Charles R., 926 Ninth St., Des Moines, Iowa (37). 1890.
 Kinnicutt, Dr. Leonard P., Polytechnic Inst., Worcester, Mass. (28).
 1883. **C**
 Kirkwood, Prof. Daniel, Arlington Ave., Riverside, Cal. (7). 1874. **A**
 Klotz, Otto Julius, Preston, Ontario, Can. (38). 1889.
 Kunz, G. F., 402 Garden St., Hoboken, N. J. (29). 1883. **E H C**
 Ladd, E. F., Fargo, No. Dakota (36). 1889. **C**
 Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**
 LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C.
 (38). 1885. **H**
 Lambert, Rev. Thomas R., D.D., Hotel Oxford, Huntington Ave., Boston,
 Mass. (18). 1874.

Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**
 Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**
 Langley, Prof. J. W., 5914 Walnut St., E. End, Pittsburgh, Pa. (28). 1875.

C B

Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**

Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**

Larkin, Edgar L., Director Knox College Observatory, Galesburg, Ill. (28). 1883. **A**

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**

Landy, Louis H., Ph.D., School of Mines, Columbia College, New York, N. Y. (28). 1890. **C**

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**

Leavenworth, Francis P., Haverford College P. O., Montgomery Co., Pa. (30). 1888. **A**

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**

Ledoux, Albert R., Ph.D., 39 W. 50th St., New York, N. Y. (26). 1881. **C**
 Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (28). 1874. **C F**

Lehmann, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. **C B**
 Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**

Libbey, Prof. William, jr., Princeton, N. J. (29). 1887. **E F**

LILLY, GEN. WM., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron) **F E**

Lindsley, J. Berrien, M.D., 185 North Spruce St., Nashville, Tenn. (1). 1874. **F**

Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**

Lloyd, John Uri, Pharmaceutical Chemist, Court and Plum Sts., Cincinnati, Ohio (38). 1890. **C F**

Lloyd, Mrs. Rachel, Box 675, Lincoln, Neb. (31). 1889. **C**

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. **F B A**

Locy, Prof. Wm. A., Lake Forest, Ill. (34). 1890. **F**

Loeb, Morris, Ph.D., Clark Univ., Worcester, Mass. (36). 1889. **C**

Lord, Prof. Nat. W., State Univ., Columbus, Ohio (29). 1881. **C**

Loud, Prof. Frank H., Colorado Springs, Col. (29). **A B**

Loudon, Prof. James, Toronto, Ontario, Can. (25). 1881. **B A**

Loughridge, Dr. R. H., Ky. Geol. Survey, Frankfort, Ky. (21). 1874. **E C**

Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. **C**

Lovering, Prof. Joseph, Harvard University, Cambridge, Mass. (2). 1875.

B A

Low, Seth, Pres. Columbia Coll., New York, N. Y. (29). 1890.

Lupton, Prof. N. T., Auburn, Lee Co., Ala. (17). 1874. **C**

Lyon, Dr. Henry, 84 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. **E H**

McBride, Prof. Thomas H., Iowa City, Iowa (38). 1890. **F**

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McCreath, Andrew S., 228 Market St., Harrisburg, Pa. (33). 1889. **C E**

McGee, W J., U. S. Geol. Survey, Washington, D. C. (27). 1882. **E**

McGill, John T., Ph.D., Vanderbilt Univ., Nashville, Tenn. (36). 1888. **C**

McLeod, Prof. C. H., McGill Univ., Montreal, P. Q., Can. (35). 1887.

A B D

McMurtrie, William, care New York Tartar Co., 68 William St., New York, N. Y. (22). 1874. **C**

McNeill, Malcolm, Lake Forest, Ill. (32). 1885. **A**

Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. **C**

Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. **B A**

Mackintosh, James B., Consolidated Gas Co., 21st St. and Ave. A, New York, N. Y. (27). 1883. **C B**

Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. **F**

Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.

Mallery, Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. **H**

MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C. (22). 1874. **I F**

Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. **E**

MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874. **F H**

Martin, Artemas, U. S. Coast Survey, Washington, D. C. (38). 1890. **A**

Martin, Prof. Daniel S., 286 West 4th St., New York, N. Y. (28). 1879.

E F

Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. **F H**

Martin, Miss Lillie J., Girls' High School, San Francisco, Cal. (32). 1886. **F C**

Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. **C E**

Martindale, Isaac C., Camden, N. J. (26). 1890. **F**

Mason, Prof. Otis T., National Museum, Washington, D. C. (25). 1877. **H**

Mason, Dr. William P., Prof. Rensselaer Polytechnic Inst., Troy, N. Y. (31). 1886. **C**

Mutthews, Washington, 1262 New Hampshire Ave., cor. 21st St., N. W., Washington, D. C. (37). 1888. **H**

- Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. **H E**
 Mayer, Prof. A. M., South Orange, N. J. (19). 1874.
 Meehan, Thomas, Germantown, Pa. (17). 1875. **F**
 Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. **B C**
 Mendenhall, Prof. T. C., U. S. C. and G. Survey, Washington, D. C. (20).
 1874. **B**
 Menocal, Anicito G., C.E., U. S. N., Navy Yard, Washington, D. C. (36).
 1888. **D**
 Merrill, Frederick J. H., Ph B., Ass't Director, New York State Museum,
 Albany, N. Y. (35). 1887. **E**
 Merriman, C. C., 1910 Surf St., Lake View, Chicago, Ill. (29). 1880. **F**
 Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885.
 A D
 Merritt, Ernest, Ithaca, N. Y. (33). 1890.
 Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. **H**
 Michael, Mrs. Helen Abbott, Torwood, Bouchurch, Isle of Wight, Eng-
 land (38). 1885. **C F**
 Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26).
 1879. **B**
 Miles, Prof. Manly, Lansing, Mich. (29). 1890. **F**
 Mills, T. Wesley, Montreal, P. Q., Can. (31). 1886. **F H**
 Minot, Dr. Charles Sedgwick, Harvard Medical School, Back Bay, Bos-
 ton, Mass. (28). 1880. **F**
 Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.
 Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. **C**
 Mooney, James, Bureau of Ethnology, Washington, D. C. (38). 1890. **H**
 Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. **B**
 D A
 Moore, Robert, C.E., 61 Vanderventer Place, St. Louis, Mo. (33). 1887.
 D B I
 Moorehead, Warren K., Zenia, Ohio (38). 1890. **H**
 Morgan, Frank H., Cornell Univ., Ithaca, N. Y. (35). 1889. **C**
 Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876.
 C B E
 Morse, Prof. E. S., Salem, Mass. (18). 1874. **F H**
 Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875.
 B C
 Moser, Lieut. Jeff. F., U. S. N., Slatington, Lehigh Co., Pa. (28). 1889. **E**
 Moses, Prof. Thomas F., Urbana University, Urbana, Ohio (25). 1883.
 H F
 Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Sta-
 tion, Newport, R. I. (22). 1874. **C**
 Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886.
 F H
 Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**
 Myers, John A., Agric. Exper. Station, Morgantown, W. Va. (30). 1889. **C**
 Nason, Frank L., 5 Union St., New Brunswick, N. J. (36). 1888. **E**

- Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (18).
 1874. C E
- Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. A B D
- Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875.
 E F H I
- Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. C
- Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. A B
- Newton, Hubert A., New Haven, Conn. (6). 1874. A
- Nichols, E. L., Ph.D., Cornell Univ., Ithaca, N. Y. (28). 1881. B C
- Nicholson, Prof. H. H., Box 675, Lincoln, Neb. (36). 1888.
- Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
- Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. B
- Nolan, Edw. J., M.D., Academy of Natural Sciences, Philadelphia, Pa.
 (29). 1890. F
- Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass.
 (29). 1884. C
- NORTON, PROF. THOMAS H., Univ. of Cincinnati, Cincinnati, Ohio (35).
 1887. C
- Novy, Frederick George, Sc.D., University of Mich., Ann Arbor, Mich.
 (36). 1889. C
- Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32).
 1885. C
- Nuttall, Mrs. Zelia, care Peabody Museum, Cambridge, Mass. (35). 1887.
 H
- Oliver, Charles A., M.D., 1507 Locust St., Philadelphia, Pa. (33). 1886.
 F H B
- Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. A B I
- Ordway, Prof. John M., Tulane University, New Orleans, La. (9). 1875.
 C
- Orton, Prof. Edward, President Ohio Agricultural and Mechanical College,
 Columbus, Ohio (19). 1875. E
- Osborn, Henry F., S.D., Princeton, N. J. (29). 1883.
- Osborn, Herbert, Ames, Iowa (32). 1884. F
- Osmond, Prof. I. Thornton, State College, Centre Co., Pa. (33). 1889.
 B A C
- Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875. F E
- Palme, Cyrus F., 305 Ellwanger & Barry Building, Rochester, N. Y. (12).
 1874. B A
- Paine, Nathaniel, Worcester, Mass. (18). 1874. H
- Palfray, Hon. Charles W., Salem, Mass. (21). 1874.
- Palmer, Chase, Ph.D., Missouri School of Mines, Rolla, Mo. (38). 1889
 C
- Parke, John G., Gen. U. S. A., 16 Lafayette Square, Washington, D. C.
 (29). 1881. D
- PARKHURST, HENRY M., Law Stenographer, 25 Chambers St., New York,
 N. Y. (23). 1874. A

- Patrick, Geo. E., Ames, Iowa (36). 1890. C
- Patterson, Harry J., College Park P. O., Md. (36). 1890. C
- Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (38). 1885. A B
- Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17). 1885. D B F
- Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. C B E
- Pedrick, Wm. R., Lawrence, Mass. (22). 1875.
- Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. H
- Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. A B
- Pengra, Charles P., M.D., 180 Dartmouth St., Boston, Mass. (34). 1887. F C
- Penrose, Dr. R. A. F., State Geol. Surv., Little Rock, Ark. (38). 1890. E
- Perkins, Prof. George H., Burlington, Vt. (17). 1882. H F E
- Peter, Alfred M., 171 Rose St., Lexington, Ky. (29). 1890. C
- Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. C
- Peters, Edw. T., P. O. Box 265, Washington, D. C. (38). 1889. I
- Pettie, Prof. William H., Ann Arbor, Mich. (24). 1875. E
- Phillips, Prof. A. W., New Haven, Conn. (24). 1879.
- Phillips, Prof. Francis C., Western University, Allegheny, Pa. (36). 1889. C
- Phillips, Henry, Jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. H I
- Phippen, Geo. D., Salem, Mass. (18). 1874. F
- Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. A B
- Pilling, James C., Box 591, Washington, D. C. (28). 1882. F H I
- Pillsbury, Prof. John H., Smith College, Northampton, Mass. (28). 1885. F H
- Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. E
- Plumb, Charles S., Purdue Univ., La Fayette, Ind. (36). 1890.
- Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. E F
- Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (38). 1887. F
- Potter, William B., Washington Univ., St. Louis, Mo. (25). 1879.
- Powell, Major J. W., U. S. Geologist, 910 M St., N. W., Washington, D. C. (28). 1875. E H
- Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. C
- Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. F
- Prentiss, D. Webster, M.D., 1101 14th St. N. W., Washington, D. C. (29). 1882. F
- Prescott, Prof. Albert B., Ann Arbor, Mich. (28). 1875. C
- Preston, E. D., Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (37). 1889. A E
- Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. A

- Procter, John R., Dir. Kentucky Geological Survey, Frankfort, Ky. (26).
1881. **E**
 Pulsifer, Wm. H., 1887 Kennett Place, St. Louis, Mo. (26). 1879. **A H**
 Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17).
1875. **E I**
 Putnam, Prof. F. W., Curator Peabody Museum American Archaeology and
Ethnology, Cambridge, Mass. (Address as Permanent Secretary
A. A. A. S., Salem, Mass.) (10). 1874. **H**
 Pynchon, Rev. T. R., Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

- Rau, Eugene A., Bethlehem, Pa. (38). 1890. **F**
 Rauch, Dr. John H., Springfield, Ill. (11). 1875.
 Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875.
E I
 Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. **F**
 Reed, E. Baynes, London, Ontario, Can. (27). 1882.
 Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. **A**
E B
 Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. **C**
 Rice, John M., Northborough, Mass. (25). 1881. **A D**
 Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18).
1874. **E F**
 Richards, Prof. Charles B., 818 York St., New Haven, Conn. (33).
1885. **D**
 Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington,
D. C. (31). 1886. **C**
 Richards, Prof. Robert H., Mass. Inst. Tech., Back Bay, Boston, Mass.
(22). 1875. **D**
 Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Back Bay, Boston,
Mass. (23). 1878. **C**
 Richardson, Clifford, Office of the Engineer Commissioner, Washington,
D. C. (30). 1884. **C**
 Ricketts, Prof. Palmer C., 17 1st St., Troy, N. Y. (38). 1887. **D A**
 Ricketts, Prof. Pierre de Peyster, School of Mines, Columbia College,
New York, N. Y. (26). 1880. **C D E**
RILEY, PROF. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington,
D. C. (17). 1874. **F H I**
 Risteen, Allen D., Hartford, Conn. (38). 1890. **A B D**
 Ritchie, E. S., Newton Highlands, Mass. (10). 1877. **B**
 Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. **I**
 Robinson, Prof. Franklin C., Brunswick, Me. (29). 1889. **C D**
 Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**
 Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. **E**
 Rockwell, Chas. H., Box 298, Tarrytown, N. Y. (28). 1883. **A D**

- Rockwood, Prof. Charles G., Jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**
- Rogers, Fairman, 147 S. Fourth St., Philadelphia, Pa. (11). 1874.
- Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. **A B D**
- Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**
- Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**
- Ross, Waldo O., 31 Otis St., Boston, Mass. (29). 1882.
- Rowland, Prof. Henry A., Baltimore, Md. (29). 1880. **B**
- Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. **A D**
- Rusby, Henry H., M.D., College of Pharmacy, New York, N. Y. (36). 1890. **F**
- Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882. **E**
- Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.
- Ryan, Harris J., Cornell Univ., Ithaca, N. Y. (38). 1890. **B**
- Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**
- Salisbury, Prof. R. D., Beloit College, Beloit, Wis. (37). 1890. **B E**
- Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**
- Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. **B A**
- Saunders, William, Director Agricultural Experiment Station, Ottawa, Ontario, Can. (17). 1874. **F**
- SCHAEBERLE, J. M., Astronomer in the Lick Observatory, San José, Cal. (34). 1886. **A**
- Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. **C B H**
- Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**
- Schweinitz, Dr. E. A. v., Dep't of Agriculture, Washington, D. C. (36). 1889. **C**
- Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**
- Scovell, M. A., Director Kentucky Agricultural Experiment Station, Lexington, Ky. (35). 1887.
- Scribner, F. Lamson, Dep't of Agric., Washington, D. C. (34). 1887. **F**
- SCUDDER, SAMUEL H., Cambridge, Mass. (18). 1874. **F**
- Seaman, W. H., Chemist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**
- Sedgwick, Prof. Wm. T., Mass. Inst. of Tech., Boston, Mass. (33). 1886. **F**
- See, Horace, 1 Broadway, New York, N. Y. (34). 1886. **D**
- Seller, Carl, M.D., 1846 Spruce St., Philadelphia, Pa. (29). 1882. **F B**
- Seymour, Arthur Bliss, Cambridge, Mass. (36). 1890. **F**
- Seymour, William P., M.D., 105 Third St., Troy, N. Y. (19). 1888. **H**
- Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**
- Shimer, Porter W., E.M., Easton, Pa. (38). 1889. **C**
- Shutt, Frank T., M.A., F.E.C., F.C.S., Chemist to the Dominion Experimental Farms, Ottawa, Ontario, Can. (38). 1889. **C**

- Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.
 Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. **D E**
- Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. **D E**
 Simonds, Prof. Frederic W., Univ. of Texas, Austin, Texas (25). 1888
E F
- Skinner, Joseph J., Massachusetts Inst. Technology, Boston, Mass. (23). 1880. **B**
- Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**
- Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. **A B**
 Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**
- Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. **C**
- Smith, Erwin F., Dep't of Agric., Washington, D. C. (34). 1890. **F**
- Smith, Prof. Eugene A., University, Ala. (20). 1877. **E C**
- Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**
- Smith, John B., Professor of Entomology, Rutgers College, New Brunswick, N. J. (32). 1884. **F**
- SMITH, QUINTIUS C., M.D., No. 617 Colo. St., Austin, Texas (26). 1881. **F**
- Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**
- Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. **F**
- Smock, Prof. John Conover, Trenton, N. J. (28). 1879. **E**
- Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**
- Snow, Benj. W., Cornell Univ., Ithaca, N. Y. (35). 1889. **B**
- Snyder, Henry, B.Sc., Miami Univ., Oxford, Ohio (30). 1888. **B C**
- Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**
- Soule, R. H., Gen. Agent, The Union Switch & Signal Co., Swissvale, Allegheny Co., Pa. (38). 1886. **D**
- Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**
- Spencer, Guilford L., Department Agriculture, Washington, D. C. (36). 1889. **C D**
- Spencer, Prof. J. William, Prof. of Geology, University of Georgia, Athens, Ga. (28). 1882. **E**
- Spencer, John W., Paxton, Sullivan Co., Ind. (20). 1874.
- Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**
- Staley, Cady, LL.D., Pres. Case School of Applied Sciences, Cleveland, Ohio (37). 1888. **D**
- Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**
- Steere, Prof. Jos. B., Ann Arbor, Mich. (34). 1890. **F H**
- Stelner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**
- STEPHENSON, W. HUDSON, Lowville, N. Y. (18). 1874. **E H**

- Sternberg, Dr. George M., Surgeon U. S. A., Medical Purveyor, San Francisco, Cal. (24). 1880. **F**
- Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B**
A C
- Stevenson, Prof. John J., Univ. of New York, New York, N. Y. (26). 1888.
- Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**
- Stone, George H., Colorado Springs, Col. (29). 1882. **E F**
- Stone, Mrs. Leander, Pres. Y. W. C. A., 8352 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**
- Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**
- Story, Wm. E., Clark Univ., Worcester, Mass. (29). 1881. **A**
- Stowell, Prof. T. B., Potsdam, N. Y. (28). 1885. **F**
- Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (28). 1885. **A**
- Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**
- Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**
- Swallow, Prof. C. G., 19½ Main St., Helena, Montana (10). 1875.
- Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**
- Tainter, Charles Sumner, 1843 S St., cor. 19, Washington, D. C. (29). 1881. **B D A**
- Taylor, H. C., Commander U. S. N., Poughkeepsie, N. Y. (30). 1889.
- Taylor, Thos., M.D., Dept of Agric., Washington, D. C. (29). 1885. **F C**
- Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**
- Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**
- Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**
- Thomson, Elihu, Thomson-Houston Electric Co., Lynn, Mass. (37). 1888. **B**
- Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**
- Thruston, Gates Phillips, Nashville, Tenn. (38). 1890. **H**
- Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (28). 1875. **D**
- Tittmann, Otto H., U. S. Coast and Geodetic Survey Office, Washington, D. C. (24). 1888. **A**
- Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. **E F**
- Towne, Henry R., Pres. Yale and Towne Manufacturing Co., Stamford, Conn. (33). 1888. **D B**
- Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**
- Tracy, Sam'l M., Agricultural College, Miss. (27). 1881. **F**
- Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**
- Trimble, Prof. Henry, 145 No. 10 St., Philadelphia, Pa. (34). 1889. **C**
- True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. **F**
- Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**
- Tucker, Willis G., M.D., Albany Med. Coll., Albany, N. Y. (29). 1888. **C**
- Tuttle, Prof. Albert H., Univ. of Virginia, Va. (17). 1874. **F**

- Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**
 Underwood, Prof. Lucien M., 411 Comstock Ave., Syracuse, N. Y. (38).
 1885. **F**
- Upham, Warren, 36 Newbury St., Somerville, Mass. (25). 1880. **E**
 Upton, Winslow, Brown Univ., Providence, R. I. (29). 1888. **A**
- Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17).
 1874. **B**
- Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**
 Van Hise, Charles R., Univ. of Wisconsin, Madison, Wis. (37). 1890.
- Van Vleck, Prof. John M., Middletown, Conn. (28). 1875. **A**
- Vasey, George, M.D., Dep't of Agric., Washington, D. C. (32). 1889. **F**
 Very, Samuel W., Lieut. Comdr. U. S. N., Robeson St., Jamaica Plain,
 Mass. (28). 1886. **A B**
- Vining, Edward P., 816 Olive St., St. Louis, Mo. (32). 1887. **H**
 Hodges, A. W., Fort Canby, Pacific Co., Washington (32). 1885. **E F**
- Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**
 Wadsworth, Prof. M. Edward, Ph.D., Director of the Michigan Mining
 School, State Geologist of Michigan, Houghton, Mich. (28). 1874. **E**
 Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25).
 1882. **E F**
- Waldo, Prof. Clarence, A., Rose Polytechnic Inst., Terre Haute, Ind. (37).
 1889. **A**
- Waldo, Leonard, S.D., Lockport, N. Y. (28). 1880. **A**
- Wallace, Wm., Ansonia, Conn. (28). 1882.
- WALLER, E., School of Mines, Columbia College, New York, N. Y. (28).
 1874.
- Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1888. **F**
 Wanner, Atreus, York, York Co., Pa. (36). 1890. **H**
- Ward, Prof. Henry A., Rochester, N. Y. (18). 1875. **F E H**
 Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26).
 1879. **E F**
- Ward, Dr. R. H., 58 Fourth St., Troy, N. Y. (17). 1874. **F B**
 Ward, Wm. E., Port Chester, N. Y. (36). 1889. **D**
- Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881.
C B
- WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**
 Warner, Worcester R., 887 Case Ave., Cleveland, Ohio (38). 1888. **A B D**
 Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**
- Warren, Dr. Joseph W., Harvard Med. School, Boston, Mass. (31). 1886. **F**
 Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A-I**
- Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**
 WATSON, PROF. WM., 107 Marlborough St., Boston, Mass. (12). 1884. **A**
 Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**
 Weber, Prof. Henry A., Ohio State Univ., Columbus, Ohio (35). 1888. **F**
 Webster, F. M., La Fayette, Ind. (35). 1890.
- Webster, Prof. N. B., Grove House, Vineland, N. J. (7). 1874. **B C E**

- Weed, Clarence M., Ohio Experimental Station, Columbus, Ohio (38).
1890.
- Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**
- Weston, Edward, 645 High St., Newark, N. J. (38). 1887. **B C D**
- Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.
- Wheeler, Orlando B., Office Mo. River Com., 1515 Lucas Place, St. Louis,
Mo. (24). 1882. **A D**
- Wheildon, W. W., Box 229, Concord, Mass. (18). 1874. **B E**
- White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**
- White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**
- WHITE, PROF. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**
- Whiteaves, J. F., Geol. Survey, Ottawa, Ontario, Can. (31). 1887. **E F**
- Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue,
New York, N. Y. (18). 1874. **E F H**
- Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883.
B A
- Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (38). 1885.
A B
- Wilbur, A. B., Middletown, N. Y. (23). 1874.
- Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**
- Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**
- Williams, Benezette, 171 La Salle St., Chicago, Ill. (38). 1887. **D**
- Williams, Charles H., M.D., C. B. and Q. Gen. Office, Chicago, Ill. (22).
1874.
- Williams, Francis H., M.D. (29). 1890.
- Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (38).
1886. **E**
- Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. **E F**
- Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. **H
F**
- Williams, J. Francis, Salem, N. Y. (31). 1890. **C E**
- Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (38). 1885. **E**
- Willis, Bailey, U. S. Geol. Survey, Washington, D. C. (36). 1890.
- Willson, Prof. Frederick N., Princeton, N. J. (38). 1887. **A D**
- Willson, Robert W., Cambridge, Mass. (30). 1890. **B A**
- Wilson, Sir Daniel, President University College, 117 Bloor St., Toronto,
Ontario, Canada (25). 1876. **H E**
- Wilson, Joseph M., Room 1036, Drexel Building, Philadelphia, Pa. (38).
1886. **D**
- Wilson, Thomas, U. S. Nat'l Museum, Washington, D. C. (36). 1888. **H**
- Wilson, William Powell, 640 No. 32nd St., Philadelphia, Pa. (38). 1889.
F
- Winchell, Horace V., 10 State St., Minneapolis, Minn. (34). 1890. **E C**
- Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874.
E H
- Wing, Henry H., Cornell Univ., Experimental Station, Ithaca, N. Y. (38).
1890.

- Winlock, Wm. C., Smithsonian Institution, Washington, D. C. (38).
1885. **A B**
- Winslow, Arthur, State Geologist, Jefferson City, Mo. (37). 1889. **E**
- Witthaus, Dr. R. A., 410 E. 26th St., New York, N. Y. (35). 1890.
- Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.
- Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. **D**
- Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32).
1884. **D A I**
- Woodward, R. S., U. S. Geol. Survey, Washington, D. C. (38). 1885.
A B D
- Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.
- Worthen, W. E., 68 Bleeker St., New York, N. Y. (36). 1888. **D**
- Wrampelmeier, Theo. J., Berkeley, Cal. (34). 1887. **C**
- Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. **E F**
- Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. **A B**
- Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. **E**
- Wright, Prof. R. Ramsay, Toronto, Ontario, Can. (38). 1890. **F**
- Wright, Prof. Thos. W., Union College, Schenectady, N. Y. (36). 1889.
- Würtele, Rev. Louis C., Acton Vale, P. Q., Can. (11). 1875. **E**
- Youmans, Wm. Jay, M.D., Popular Science Monthly, 1-5 Bond St.,
New York, N. Y. (28). 1889. **F C**
- Young, A. V. E., Northwestern Univ., Evanston, Ill. (38). 1886. **C B**
- Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton,
N. J. (18). 1874. **A B D**
- Ziwet, Alexander, 6 N. Division St., Ann Arbor, Mich. (38). 1890. **A**

[747 FELLOWS.]

SUMMARY.—PATRONS, 8; MEMBERS, 1185; HONORARY FELLOWS, 2; FELLOWS, 745.
MAY 14, 1891, TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1935.

DECEASED MEMBERS.

[Unless by special vote of the Council, the names of those only who are members of the Association at the time of their decease will be included in this list. Information of the date and place of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

- Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.
Abert, John James, Washington, D. C. (1). Born in Shepherdstown, Va., Sept. 17, 1788. Died in Washington, D. C., Sept. 27, 1863.
Adams, Charles Baker, Amherst, Mass. (1). Born in Dorchester, Mass., Jan. 11, 1814. Died in St. Thomas, W. I., Jan. 19, 1853.
Adams, Edwin F., Charlestown, Mass. (18).
Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.
Agassiz, Louis, Cambridge, Mass. (1). Born in Parish of Motier, Switzerland, May 28, 1807. Died in Cambridge, Mass., Dec. 14, 1873.
Ainsworth, J. G., Barry, Mass. (14).
Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.
Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.
Allen, Zachariah, Providence, R. I. (1). Born in Providence, R. I., Sept. 15, 1795. Died March 17, 1882.
Allston, Robert Francis Withers, Georgetown, S. C. (3). Born in All Saints Parish, S. C., April 21, 1801. Died near Georgetown, S. C., April 7, 1864.
Alvord, Benjamin, Washington, D. C. (17). Born in Rutland, Vt., Aug. 18, 1813. Died Oct. 16, 1884.
Ames, M. P., Springfield, Mass. (1). Born in 1808. Died April 23, 1847.
Andrews, Ebenezer Baldwin, Lancaster, Ohio (7). Born in Danbury, Conn., April 29, 1821. Died in Lancaster, Ohio, Aug. 14, 1880.
Anthony, Charles H., Albany, N. Y. (6). Died in 1874.
Appleton, Nathan, Boston, Mass. (1). Born in New Ipswich, N. H., Oct. 6, 1779. Died July 14, 1861.
Armstrong, John W., Fredonia, N. Y. (24).
Ashburner, Charles A., Pittsburgh, Pa. (31).
Ashburner, Wm., San Francisco, Cal. (29). Born in Stockbridge, Mass., March, 1831. Died in San Francisco, Cal., April 20, 1887.
Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.
Aufrecht, Louis, Cincinnati, Ohio (80).

Baba, Tatul, New York, N. Y. (36).
Bache, Alexander Dallas, Washington, D. C. (1). Born in Philadelphia, Pa., July 19, 1806. Died at Newport, R. I., Feb. 17, 1867.

- Bache, Franklin, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Oct. 25, 1792. Died March 19, 1864.
- Bailey, Jacob Whitman, West Point, N. Y. (1). Born in Auburn, Mass., April 29, 1811. Died in West Point, N. Y., Feb. 26, 1857.
- Baird, Spencer Fullerton, Washington, D. C. (1). Born in Reading, Pa., Feb. 3, 1823. Died in Wood's Holl, Mass., Aug. 19, 1887.
- Bardwell, F. W., Lawrence, Kan. (18). Died in 1878.
- Barnard, F. A. P., New York, N. Y. (7). Born in Sheffield, Mass., May 5, 1809. Died in New York, April 27, 1889.
- Barnard, John Gross, New York, N. Y. (14). Born in Sheffield, Mass., May 19, 1815. Died in Detroit, Mich., May 14, 1882.
- Barrett, Dwight H., Baltimore, Md. (36). Died in March, 1889.
- Barrett, Moses, Milwaukee, Wis. (21). Died in 1878.
- Barry, Redmond, Melbourne, Australia (25).
- Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.
- Bassnett, Thomas, Jacksonville, Fla. (8). Born 1807. Died in Jacksonville, Fla., Feb. 16, 1886.
- Bayne, Herbert Andrew, Kingston, Ont., Can. (29). Born in Londonderry, Nova Scotia, Aug. 16, 1846. Died in Pictou, Can., Sept. 16, 1886.
- Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.
- Beck, C. F., Philadelphia, Pa. (1).
- Beck, Lewis Caleb, New Brunswick, N. J. (1). Born in Schenectady, N. Y., Oct. 4, 1798. Died April 20, 1858.
- Beck, Theodoric Romeyn, Albany, N. Y. (1). Born in Schenectady, N. Y., Aug. 11, 1791. Died in Utica, N. Y., Nov. 19, 1855.
- Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.
- Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.
- Belknap, William B., Louisville, Ky. (29).
- Bell, Samuel N., Manchester, N. H. (7). Born in Chester, N. H., March 25, 1829. Died in Manchester, N. H., Feb. 8, 1889.
- Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.
- Benedict, George Wyllis, Burlington, Vt. (16). Born Jan. 11, 1796. Died Sept. 28, 1871.
- Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.
- Binney, Amos, Boston, Mass. (1). Born in Boston, Mass., Oct. 18, 1803. Died in Rome, Feb. 18, 1847.
- Binney, John, Boston, Mass. (8).
- Blackie, Geo. S., Nashville, Tenn. (26).
- Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.
- Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.
- Blake, Francis C., Mansfield Valley, Pa. (29). Died Feb. 21, 1891.
- Blake, Homer Crane, New York, N. Y. (28). Born in Cleveland, Ohio, Feb. 1, 1822. Died in New York, N. Y., Jan. 20, 1880.
- Blanding, William, ——, R. I. (1).

- Blatchford, Thomas W., Troy, N. Y. (6).
- Blatchley, Miss S. L., New Haven, Conn. (19). Died March 18, 1878.
- Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
- Bomford, George, Washington, D. C. (1). Born in New York, N. Y., 1780. Died in Boston, Mass., March 25, 1848.
- Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.
- Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
- Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
- Braithwaite, Jos., Chambly, C. W. (11).
- Briggs, Albert D., Springfield, Mass. (18). Died Feb. 20, 1881.
- Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
- Brigham, Charles Henry, Ann Arbor, Mich. (17). Born in Boston, Mass., July 27, 1820. Died Feb. 19, 1879.
- Bross, William, Chicago, Ill. (7). Died in 1890.
- Brown, Andrew, Natchez, Miss. (1).
- Brown, Horace, Salem, Mass. (27). Died in July, 1883.
- Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.
- Burbank, L. S., Woburn, Mass. (18).
- Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.
- Burnap, George Washington, Baltimore, Md. (12). Born in Merrimack, N. H., Nov. 30, 1802. Died in Philadelphia, Pa., Sept. 8, 1859.
- Burnett, Waldo Irving, Boston, Mass. (1). Born in Southborough, Mass., July 12, 1828. Died in Boston, Mass., July 1, 1854.
- Butler, Thomas Belden, Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1878.
- Cairns, Frederick A., New York, N. Y. (27). Died in 1879.
- Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.
- Carpenter, Thornton, Camden, S. C. (7).
- Carpenter, William M., New Orleans, La. (1).
- Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.
- Case, William, Cleveland, Ohio (6).
- Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died in Providence, R. I., Jan. 8, 1877.
- Chadbourne, Paul Ansel, Amherst, Mass. (10). Born in North Berwick, Me., Oct. 21, 1828. Died Feb. 28, 1883.
- Chapman, Nathaniel, Philadelphia, Pa. (1). Born in Alexandria Co., Va., May 28, 1780. Died July 1, 1853.
- Chase, Pliny Earle, Haverford College, Pa. (18). Born in Worcester, Mass., Aug. 18, 1820.
- Chase, Stephen, Hanover, N. H. (2). Born in 1818. Died Aug. 5, 1851.
- Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 18, 1870.
- Cheesman, Louis Montgomery, Hartford, Conn. (32). Born in 1858. Died in Jan., 1885.

- Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.
- Chevreul, Michel Eugène, Paris, France (35). Born in Angiers, France, Aug. 31, 1786. Died April 9, 1889.
- Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.
- Clark, Henry James, Cambridge, Mass. (18). Born in Easton, Mass., June 22, 1826. Died in Amherst, Mass., July 1, 1878.
- Clark, Joseph, Cincinnati, Ohio (5).
- Clark, Patrick, Rahway, N. J. (38). Died March 5, 1887.
- Clarke, A. B., Holyoke, Mass. (18).
- Cleaveland, C. H., Cincinnati, Ohio (9).
- Cleveland, A. B., Cambridge, Mass. (2).
- Coffin, James Henry, Easton, Pa. (1). Born in Northampton, Mass., Sept. 6, 1806. Died Feb. 6, 1873.
- Coffin, John H. C., Washington, D. C. (1). Born in Wiscasset, Maine, Sept. 14, 1815. Died in Washington, D. C., Jan. 8, 1890.
- Coffinberry, Wright Lewis, Grand Rapids, Mich. (20). Born in Lancaster, Ohio, April 5, 1807. Died in Grand Rapids, Mich., March 26, 1889.
- Colburn, E. M., Peoria, Ill. (33). Born in Rome, N. Y., Sept. 18, 1813. Died in Peoria, Ill., May 29, 1890.
- Cole, Frederick, Montreal, Can. (81). Died in 1887.
- Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1853.
- Coleman, Henry, Boston, Mass. (1).
- Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.
- Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in New Jersey, June 21, 1808. Died Aug. 9, 1877.
- Cook, George H., New Brunswick, N. J. (4). Born in Hanover, Morris County, in 1818. Died in New Brunswick, N. J., Sept. 22, 1889.
- Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.
- Cooper, William, Hoboken, N. J. (9). Died in 1864.
- Cope, Mary S., Germantown, Pa. (38). Born in Germantown, Pa., July 18, 1853. Died in Germantown, Jan. 4, 1888.
- Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.
- Corning, Erastus, Albany, N. Y. (6). Born in Norwich, Conn., Dec. 14, 1794. Died April 9, 1872.
- Costin, M. P., Fordham, N. Y. (80). Died June 8, 1884.
- Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.
- Cramp, John Mockett, Wolfville, N. S. (11). Born in Kent, England, July 25, 1796. Died Dec. 6, 1881.
- Crehore, John D., Cleveland, Ohio (24).
- Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.
- Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.
- Crosby, Alpheus, Salem, Mass. (10). Born in Sandwich, N. H., Oct. 13, 1810. Died April 17, 1874.

- Crosby, Thomas Russell, Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.
- Croswell, Edwin, Albany, N. Y. (6). Born in Catskill, N. Y., May 29, 1797. Died June 18, 1871.
- Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.
- Cummings, Joseph, Evanston, Ill. (13). Born in Falmouth, Me., March 8, 1817. Died in Evanston, Ill., May 7, 1890.
- Curry, W. F., Geneva, N. Y. (11).
- Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.
- Da Costa, Chas. M., New York, N. Y. (36). Died in 1890.
- Dalrymple, Edwin Augustine, Baltimore, Md. (11). Born in Baltimore, Md., June 4, 1817. Died Oct. 30, 1881.
- Danforth, Edward, Elmira, N. Y. (11). Died in Elmira, N. Y., June 18, 1888.
- Davenport, H. W., Washington, D. C. (30).
- Day, Austin G., New York, N. Y. (29). Died Dec. 28, 1889.
- Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1878.
- Dean, Amos, Albany, N. Y. (6). Born in Barnard, Vt., Jan. 16, 1808. Died Jan. 26, 1868.
- Dearborn, George H. A. S., Roxbury, Mass. (1).
- Dekay, James Ellsworth, New York, N. Y. (1). Born in New York, 1792. Died Nov. 21, 1851.
- Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.
- De Laski, John, Carver's Harbor, Me. (18).
- Devereux, John Henry, Cleveland, Ohio (18). Born in Boston, Mass., April 5, 1832. Died in Cleveland, Ohio, March 17, 1886.
- Dewey, Chester, Rochester, N. Y. (1). Born in Sheffield, Mass., Oct. 25, 1781. Died Dec. 15, 1867.
- Dexter, G. M., Boston, Mass. (11).
- Dillingham, W. A. P., Augusta, Me. (17).
- Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.
- Dinwiddie, Hardaway H., College Station, Texas (32). Died Dec. 11, 1887.
- Dinwiddie, Robert, New York, N. Y. (1). Born in Dumfries, Scotland, July 23, 1811. Died in New York, N. Y., July 12, 1888.
- Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.
- Doggett, George Newell, Chicago, Ill. (38). Born in Chicago, Ill., Dec. 19, 1858. Died in Fredericksburg, Va., Jan. 15, 1887.
- Doggett, Mrs. Kate Newell, Chicago, Ill. (17). Born in Castleton, Vt., Nov. 5, 1828. Died in Havana, Cuba, March 13, 1884.
- Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.
- Doolittle, L., Lenoxville, C. E. (11). Died in 1862.
- Dorr, Ebenezer Pearson, Buffalo, N. Y. (25). Born in Hartford, Vt. Died in Buffalo, N. Y., April 29, 1882.

- Draper, Henry, New York, N. Y. (28). Born in New York, N. Y., March 7, 1887. Died Nov. 20, 1882.
- Ducatel, Julius Timoleon, Baltimore, Md. (1). Born in Baltimore, Md., June 6, 1798. Died April 25, 1849.
- Duffield, George, Detroit, Mich. (10). Born in Strasburg, Pa., July 4, 1794. Died in Detroit, Mich., June 26, 1869.
- Dumont, A. H., Newport, R. I. (14).
- Dun, Walter Angus, Cincinnati, Ohio (31). Born March 1, 1857. Died Nov. 7, 1887.
- Duncan, Lucius C., New Orleans, La. (10). Born in 1801. Died Aug. 9, 1855.
- Dunn, R. P., Providence, R. I. (14).
- Eads, James Buchanan, New York, N. Y. (27). Born May 28, 1820. Died March 8, 1887.
- Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.
- Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
- Elliott, Ezekiel Brown, Washington, D. C. (10). Born July 16, 1823. Died May 24, 1888.
- Elsberg, Louis, New York, N. Y. (23). Born in Iserlohn, Prussia, April 2, 1836. Died in New York, N. Y., Feb. 19, 1885.
- Elwyn, Alfred Langdon, Philadelphia, Pa. (1). Born in Portsmouth, N. H., July 9, 1804. Died in Philadelphia, Pa., March 15, 1884.
- Ely, Charles Arthur, Elyria, Ohio (4).
- Emerson, Geo. Barrell, Boston, Mass. (1). Born in Kennebunk, Me., Sept. 12, 1797. Died March 14, 1881.
- Emmons, Ebenezer, Williamstown, Mass. (1). Born in Middlefield, Mass., May 16, 1799. Died October 1, 1863.
- Engelmann, George, St. Louis, Mo. (1). Born in Frankfort-on-the Main, Germany, Feb. 2, 1809. Died Feb. 4, 1884.
- Engstrom, A. B., Burlington, N. J. (1).
- Eustis, Henry Lawrence, Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.
- Evans, Edwin, Streator, Ill. (30). Died May 5, 1889.
- Everett, Edward, Boston, Mass. (2). Born in Dorchester, Mass., April 11, 1794. Died in Boston, Mass., Jan. 15, 1865.
- Ewing, Thomas, Lancaster, Ohio (5). Born in Ohio Co., Va., Dec. 28, 1789. Died Oct. 26, 1871.
- Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.
- Farnam, J. E., Georgetown, Ky. (26).
- Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.
- Felton, Samuel Morse, Philadelphia, Pa. (29). Born in Newbury, Mass., July 19, 1809. Died in Philadelphia, Pa., Jan. 24, 1889.
- Ferris, Isaac, New York, N. Y. (6). Born in New York, Oct. 9, 1798. Died in Roselle, N. J., June 16, 1873.
- Feuchtwanger, Lewis, New York, N. Y. (11). Born in Fürth, Bavaria, Jan. 11, 1805. Died in New York, N. Y., June 25, 1876.

- Ficklin, Joseph, Columbia, Mo. (20). Born in Winchester, Ky., Sept. 9, 1833. Died in Columbia, Mo., Sept. 6, 1887.
- Fillmore, Millard, Buffalo, N. Y. (7). Born in New York, Jan. 7, 1800. Died March 8, 1874.
- Fisher, Mark, Trenton, N. J. (10).
- Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.
- Fitch, O. H., Ashtabula, Ohio (7). Born in 1808. Died Sept. 17, 1882.
- Floyd, Richard S., San Francisco, Cal. (34). Died Oct. 17, 1890.
- Foote, Herbert Carrington, Cleveland, Ohio (36). Born in 1852. Died in Cleveland, Aug. 24, 1888.
- Forbush, E. B., Buffalo, N. Y. (15).
- Force, Peter, Washington, D. C. (4). Born in New Jersey, Nov. 26, 1790. Died in Washington, D. C., Jan. 23, 1868.
- Ford, A. C., Nashville, Tenn. (26).
- Forshey, Caleb Goldsmith, New Orleans, La. (21). Born in Somerset Co., Pa., July 18, 1812. Died in Carrollton, La., July 25, 1881.
- Foster, John Wells, Chicago, Ill. (1). Born in Brimfield, Mass., March 4, 1815. Died in Chicago, Ill., June 29, 1873.
- Foucon, Felix, Madison, Wis. (18).
- Fowle, Wm. Bentley, Boston, Mass. (1). Born in Boston, Mass., Oct. 17, 1795. Died Feb. 6, 1865.
- Fox, Charles, Grosse Ile, Mich. (7).
- Fox, Joseph G., Easton, Pa. (81). Born in Adams, N. Y., Sept. 7, 1833. Died in Easton, Pa., Dec. 27, 1889.
- Frazer, John Fries, Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.
- Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 3, 1855. Died Feb. 2, 1886.
- French, John William, West Point, N. Y. (11). Born in Connecticut, about 1810. Died in West Point, N. Y., July 8, 1871.
- Fuller, H. Weld, Boston, Mass. (29). Died Aug. 14, 1889.
- Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.
- Gardiner, Frederic, Middletown, Conn. (28). Born in Gardiner, Me., Oct. 22, 1822. Died in Middletown, Conn., July 17, 1889.
- Garrison, H. D., Chicago, Ill. (31). Died in Feb., 1891.
- Gavit, John E., New York, N. Y. (1). Born in New York, Oct. 29, 1819. Died in Stockbridge, Mass., Aug. 25, 1874.
- Gay, Martin, Boston, Mass. (1). Born in 1804. Died Jan. 12, 1850.
- Gibbon, J. H., Charlotte, N. C. (8).
- Gillespie, William Mitchell, Schenectady, N. Y. (10). Born in New York, N. Y., 1816. Died in New York, Jan. 1, 1868.
- Gilmor, Robert, Baltimore, Md. (1).
- Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.
- Goldmark, J., New York, N. Y. (29). Died in April, 1882.
- Gould, Augustus Addison, Boston, Mass. (11). Born April 28, 1805. Died Sept. 15, 1866.

- Gould, Benjamin Apthorp, Boston, Mass. (2). Born in Lancaster, Mass., June 15, 1787. Died Oct. 24, 1859.
- Graham, James D., Washington, D. C. (1). Born in Virginia, 1799. Died in Boston, Mass., Dec. 28, 1865.
- Gray, Alonzo, Brooklyn, N. Y. (18). Born in Townshend, Vt., Feb. 21, 1808. Died in Brooklyn, N. Y., March 10, 1860.
- Gray, Asa, Cambridge, Mass. (1). Born in Paris, N. Y., Nov. 18, 1810. Died in Cambridge, Mass., Jan. 30, 1888.
- Gray, James H., Springfield, Mass. (6).
- Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.
- Greene, Everett W., Madison, N. J. (10). Died in 1864.
- Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.
- Greer, James, Dayton, Ohio (20). Died in Feb., 1874.
- Griffith, Robert Eglesfield, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 18, 1798. Died June 26, 1854.
- Griswold, John Augustus, Troy, N. Y. (19). Born Nov. 11, 1818. Died Oct. 31, 1872.
- Guest, William E., Ogdensburg, N. Y. (6).
- Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.
- Habel, Louis, Northfield, Vt. (84).
- Hackley, Charles William, New York, N. Y. (4). Born in Herkimer Co., N. Y., March 9, 1809. Died in New York, N. Y., January 10, 1861..
- Hadley, George, Buffalo, N. Y. (6). Born June, 1818. Died Oct. 16, 1877.
- Haldeman, Samuel Stehman, Chickies, Pa. (1). Born Aug. 12, 1812. Died Sept. 10, 1880.
- Hale, Enoch, Boston, Mass. (1). Born in Westhampton, Mass., Jan. 29, 1790. Died in Boston, Mass., Nov. 12, 1848.
- Hamilton, Jno. M., Coudersport, Pa. (83).
- Hampson, Thomas, Washington, D. C. (38).
- Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.
- Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.
- Hare, Robert, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 17, 1781. Died in Philadelphia, May 15, 1858.
- Harger, Oscar, New Haven, Conn. (25). Born in Oxford, Conn., Jan. 12, 1843. Died in New Haven, Conn., Nov. 6, 1887.
- Harlan, Joseph G., Haverford, Pa. (8).
- Harlan, Richard, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Sept. 19, 1796. Died in New Orleans, La., Sept. 30, 1848.
- Harris, Thaddeus William, Cambridge, Mass. (1). Born in Dorchester, Mass., Nov. 12, 1795. Died in Cambridge, Mass., Jan. 16, 1856.
- Harrison, A. M., Plymouth, Mass. (29).
- Harrison, Benjamin Franklin, Wallingford, Conn. (11). Born April 19, 1811. Died April 28, 1886.
- Harrison, Jos., jr., Philadelphia, Pa. (12). Born in Philadelphia, Pa., Sept. 20, 1810. Died in Philadelphia, March 27, 1874.
- Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1858.

- Hartt, Charles Frederick, Ithaca, N. Y. (18). Born in Nova Scotia, Aug. 20, 1840. Died March 18, 1878.
- Haven, Joseph, Chicago, Ill. (17). Born in Dennis, Mass., Jan. 4, 1816. Died May 23, 1874.
- Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.
- Hayden, Ferdinand Vandevere, Philadelphia, Pa. (29). Born in Westfield, Mass., Sept. 7, 1829. Died Dec. 22, 1887.
- Hayden, Horace H., Baltimore, Md. (1). Born in Winsor, Conn., Oct. 13, 1769. Died in Baltimore, Md., Jan. 26, 1844.
- Hayes, George E., Buffalo, N. Y. (15).
- Hayward, James, Boston, Mass. (1). Born in Concord, Mass., June 12, 1786. Died in Boston, Mass., July 27, 1866.
- Hazen, William Babcock, Washington, D. C. (30). Born in Hartford, Vt., Sept. 27, 1830. Died Jan. 16, 1887.
- Hedrick, Benjamin Sherwood, Washington, D. C. (19). Born in 1826. Died Sept. 2, 1886.
- Heighway, A. E., Cincinnati, Ohio (29). Born Dec. 26, 1820. Died Jan. 24, 1888.
- Hempstead, G. S. B., Portsmouth, Ohio (29). Born in 1795. Died July 9, 1883.
- Henry, Joseph, Washington, D. C. (1). Born in Albany, N. Y., Dec. 17, 1797. Died May 18, 1878.
- Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.
- Hicks, William C., New York, N. Y. (84). Died in 1885.
- Hilgard, Julius Erasmus, Washington, D. C. (4). Born in Zweibrücken, Bavaria, Jan. 7, 1825. Died in Washington, D. C., May 8, 1891.
- Hilgard, Theodore Charles, St. Louis, Mo. (17). Born in Zweibrücken, Bavaria, Feb. 28, 1828. Died March 5, 1875.
- Hill, Walter N., Chester, Pa. (29). Born Apr. 15, 1846. Died Mar. 29, 1884.
- Hincks, William, Toronto, C. W. (11). Born in 1801. Died July, 1871.
- Hitchcock, Edward, Amherst, Mass. (1). Born in Deerfield, Mass., May 24, 1793. Died Feb. 27, 1864.
- Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.
- Hodgson, W. B., Savannah, Ga. (10). Born 1815.
- Holbrook, John Edwards, Charleston, S. C. (1). Born in Beaufort, S. C., Dec. 30, 1796. Died in Norfolk, Mass., Sept. 8, 1871.
- Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.
- Holmes, Edward J., Boston, Mass. (29). Died in July, 1884.
- Homes, Henry A., Albany, N. Y. (11). Born in Boston, Mass., March 10, 1812. Died in Albany, N. Y., Nov. 8, 1887.
- Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.
- Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.
- Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.
- Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.

- Hoppock, Albert E., Hastings-on-Hudson, N. Y. (29).
Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.
Horton, William, Craigville, N. Y. (1).
Hosford, Benj. F., Haverhill, Mass. (18). Died in 1864.
Hough, Franklin Benjamin, Lowville, N. Y. (4). Born in Martinsburgh, N. Y., July 20, 1822. Died June 11, 1885.
Houghton, Douglas, Detroit, Mich. (1). Born in Troy, N. Y., Sept. 21, 1809. Died Oct. 18, 1845.
Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.
Howland, Edward Perry, Washington, D. C. (29). Born in Ledyard, N. Y., July 20, 1825. Died in Harrisburg, Pa., Sept. 12, 1888.
Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Howland, Theodore, Buffalo, N. Y. (15).
Hunt, Edward Bissell, Washington, D. C. (2). Born in Livingston Co., N. Y., June 15, 1822. Died in Brooklyn, N. Y., Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born in Quincy, Mass., March 21, 1804. Died in Brooklyn, N. Y., March 2, 1858.
Hyatt, Theodore, Chester, Pa. (80).
Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).
Jackson, Charles Thomas, Boston, Mass. (1). Born in Plymouth, Mass., June 21, 1805. Died Aug. 28, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Hosmer A., Chicago, Ill. (17). Died in Chicago, Feb. 26, 1891.
Johnson, Walter Rogers, Washington, D. C. (1). Born in Leominster, Mass., June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1888.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 8, 1883.
Jones, James H., Boston, Mass. (28).
Kedzie, W. K., Oberlin, Ohio (25). Born in Kalamazoo, Mich., July 5, 1851. Died in Lansing, Mich., Apr. 10, 1880.
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (18). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 18, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 8, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (8). Born in Scotland, June 8, 1788. Died Nov. 12, 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 8, 1886.

- Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.
- Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase Allen, Milwaukee, Wis. (8). Born in Palmyra, N. Y., March 7, 1811. Died in Oconomowoc, Wis., Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (83). Born Sept. 20, 1829. Died Aug. 28, 1887.
LaRoche, Réné, Philadelphia, Pa. (12). Born in Philadelphia, Pa., 1795. Died in Philadelphia, Dec., 1872.
Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.
Lawford, Frederick, Montreal, Canada (11). Died in 1866.
Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.
Lea, Isaac, Philadelphia, Pa. (1). Born in Wilmington, Del., March 4, 1792. Died Dec. 8, 1886.
Le Conte, John Lawrence, Philadelphia, Pa. (1). Born in New York, May 13, 1825. Died Nov. 15, 1883.
Lederer, Baron von, Washington, D. C. (1).
Leidy, Joseph, Philadelphia, Pa. (7). Born in Philadelphia, Sept. 9, 1823. Died in Philadelphia, April 30, 1891.
Leonard, Reusselaer, Mauch Chunk, Pa. (38). Born in Hancock, N. Y., April 12, 1821. Died in Mauch Chunk, Pa., Oct. 26, 1888.
Lewis, Henry Carvill, Philadelphia, Pa. (26). Born in Philadelphia, Pa., Nov. 16, 1858. Died in Manchester, England, July 21, 1888.
Libbey, Joseph, Georgetown, D. C. (31). Died July 20, 1886.
Lieber, Oscar Montgomery, Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.
Lincklaen, Ledyard, Cazenovia, N. Y. (1). Born in Cazenovia, N. Y., Oct. 17, 1820. Died April 25, 1864.
Linsley, James Harvey, Stafford, Conn. (1). Born in Northford, Conn., May 5, 1787. Died in Stratford, Conn., Dec. 26, 1848.
Lockwood, Moses B., Providence, R. I. (9). Died in 1872.
Logan, William Edmond, Montreal, Canada (1). Born in Montreal, Canada, April 23, 1798. Died in Wales, June 22, 1875.
Loiseau, Emile F., Brussels, Belgium (38). Died April 30, 1886.
Loomis, Elias, New Haven, Conn. (1). Born in Willington, Conn., Aug. 7, 1811. Died in New Haven, Conn., Aug. 15, 1889.
Loosey, Charles F., New York, N. Y. (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.
Lull, Edward Phelps, Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.
Lyford, Moses, Springfield, Mass. (22). Born in Mt. Vernon, Me., Jan. 31, 1816. Died in Portland, Me., Aug. 4, 1887.

- Lyman, Chester Smith, New Haven, Conn. (4). Born in Manchester, Conn., Jan. 18, 1814. Died in New Haven, Conn., in 1889.
- Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.
- M'Conihe, Isaac, Troy, N. Y. (5).
- McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.
- McElrath, Thomas, New York, N. Y. (36). Born in Williamsport, Pa., May 1, 1807. Died in New York, N. Y., June 6, 1888.
- McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1888.
- McFarland, Walter, New York, N. Y. (36). Died July 22, 1888.
- MacGregor, Donald, Houston, Texas (38). Died in Oct., 1887.
- McLachlan, J. S., Montreal, Can. (31).
- McMahon, Mathew, Albany, N. Y. (11).
- Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
- Macfarlane, James, Towanda, Pa. (29). Died in 1885.
- Maffet, Wm. Ross, Wilkes Barre, Pa. (38). Died in June, 1890.
- Mahan, Dennis Hart, West Point, N. Y. (9). Born in New York, N. Y., April 2, 1802. Died in New York, Sept. 16, 1871.
- Marler, George L., Montreal, Can. (31).
- Marsh, Dexter, Greenfield, Mass. (1). Born in Montague, Mass., Aug. 22, 1806. Died in Greenfield, Mass., April 2, 1853.
- Marsh, James E., Roxbury, Mass. (10).
- Martin, Benjamin Nichols, New York, N. Y. (28). Born in Mount Holly, N. J., Oct. 20, 1816. Died in New York, N. Y., Dec. 26, 1888.
- Mather, William Williams, Columbus, Ohio (1). Born in Brooklyn, Conn., May 24, 1804. Died in Columbus, Ohio, Feb. 27, 1859.
- Mande, John B., St. Louis, Mo. (27). Died in April, 1879.
- Maupin, S., Charlottesville, Va. (10).
- May, Abigail Williams, Boston, Mass. (29). Born in Boston, April 21, 1829. Died in Boston, Nov. 30, 1888.
- Meade, George Gordon, Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
- Meek, Fielding Bradford, Washington, D. C. (6). Born Dec. 10, 1817. Died Dec. 21, 1876.
- Meigs, James Altkem, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
- Minifie, Wm., Baltimore, Md. (12). Born Aug. 14, 1805. Died Oct. 24, 1880.
- Mitchel, Ormsby MacKnight, Cincinnati, Ohio (3). Born in Union Co., Ky., July 28, 1810. Died in Beaufort, S. C., Oct. 30, 1862.
- Mitchell, Miss Maria, Lynn, Mass. (4). Born in Nantucket, Mass., Aug. 1, 1818. Died in Lynn, 1889.
- Mitchell, William, Poughkeepsie, N. Y. (2). Born in Nantucket, Mass., Dec. 20, 1791. Died in Poughkeepsie, N. Y., April 19, 1868.
- Mitchell, Wm. H., Florence, Ala. (17).
- Monroe, Nathan, Bradford, Mass. (6). Born in Minot, Me., May 16, 1804. Died in Bradford, Mass., July 8, 1866.

- Monroe, William, Concord, Mass. (18). Died April 27, 1877.
- Morgan, Lewis Henry, Rochester, N. Y. (10). Born near Aurora, N. Y., Nov. 21, 1818. Died Dec. 17, 1881.
- Morgan, Mrs. Mary E., Rochester, N. Y. (81). Died in 1884.
- Morris, John B., Nashville, Tenn. (26).
- Morton, Samuel George, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 26, 1799. Died in Philadelphia, May 15, 1851.
- Mott, Alexander B., New York, N. Y. (36). Died Aug. 12, 1889.
- Mudge, Benjamin Franklin, Manhattan, Kansas (25). Born in Orrington, Me., Aug. 11, 1817. Died Nov. 21, 1879.
- Muir, William, Montreal, Can. (81). Died July, 1885.
- Mussey, William Heberdon, Cincinnati, Ohio (30). Born Sept. 30, 1818. Died Aug. 1, 1882.
- Nagel, Herman, St. Louis, Mo. (80). Born in Tritzwalk, Germany, May 28, 1820. Died in St. Louis, Mo., Feb. 18, 1889.
- Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.
- Newton, E. H., Cambridge, N. Y. (1).
- Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.
- Nichols, William Ripley, Boston, Mass. (18). Born April 30, 1847. Died July 14, 1886.
- Nicholson, Thomas, New Orleans, La. (21).
- Nicollet, Jean Nicholas, Washington, D. C. (1). Born in Savoy, France, July 24, 1786. Died in Washington, D. C., Sept. 11, 1848.
- Norton, John Pitkin, New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.
- Norton, William Augustus, New Haven, Conn. (6). Born in East Bloomfield, N. Y., Oct. 25, 1810. Died Sept. 21, 1883.
- Noyes, James Oscar, New Orleans, La. (21). Born in Niles, N. Y., June 14, 1829. Died in New Orleans, La., Sept. 11, 1872.
- Nutt, Cyrus, Bloomington, Ind. (20). Born in Trumbull Co., Ohio, Sept. 4, 1814. Died in Bloomington, Aug. 28, 1875.
- Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.
- Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.
- Ogden, William Butler, High Bridge, N. Y. (17). Born in New York, N. Y., 1805. Died in New York, Aug. 8, 1877.
- Oliver, Miss Mary E., Ithaca, N. Y. (20).
- Olmsted, Alexander Fisher, New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.
- Olmsted, Denison, New Haven, Conn. (1). Born in East Hartford, Conn., June 18, 1791. Died in New Haven, Conn., May 18, 1859.
- Olmsted, Denison, Jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.
- Orton, James, Poughkeepsie, N. Y. (18). Born in Seneca Falls, N. Y., April 21, 1830. Died in Peru, S. A., Sept. 24, 1877.
- Osbun, Isaac J., Salem, Mass. (29).

- Otis, George Alexander, Washington, D. C. (10). Born in Boston, Mass., Nov. 12, 1830. Died Feb. 28, 1881.
- Owen, Richard, New Harmony, Ind. (20). Born in Scotland, Jan. 6, 1810. Died in New Harmony, March 24, 1890.
- Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.
- Painter, Jacob, Lima, Pa. (28). Died in 1876.
- Pauter, Minshall, Lima, Pa. (7).
- Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.
- Parkman, Samuel, Boston, Mass. (1). Born in 1816. Died Dec. 15, 1854.
- Parry, Charles C., Davenport, Iowa (6). Born in Admington, Worcester-shire, Eng., Aug. 28, 1823. Died in Davenport, Iowa, Feb. 20, 1890.
- Parsons, Henry Betts, New York, N. Y. (30). Born Nov. 20, 1855. Died Aug. 21, 1885.
- Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.
- Pearson, H. G., New York, N. Y. (36).
- Pease, Rufus D., Philadelphia, Pa. (33). Died in 1890.
- Peirce, Benjamin Osgood, Beverly, Mass. (18). Born in Beverly, Sept. 26, 1812. Died in Beverly, Nov. 12, 1888.
- Peirce, Benjamin, Cambridge, Mass. (1). Born in Salem, Mass., April 4, 1809. Died in Cambridge, Mass., Oct. 6, 1880.
- Perch, Bernard, Frankford, Pa. (35). Born in 1850. Died in 1887.
- Perkins, George Roberts, Utica, N. Y. (1). Born in Otsego Co., N. Y., May 3, 1812. Died in New Hartford, N. Y., Aug. 22, 1876.
- Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.
- Perry, John B., Cambridge, Mass. (16). Born in 1820. Died Oct. 3, 1872.
- Perry, Matthew Calbraith, New York, N. Y. (10). Born in South Kings-ton, R. I., 1795. Died in New York, March 4, 1858.
- Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Born in Ber-lin, Conn., July 15, 1793. Died in Berlin, July 15, 1884.
- Philbrick, Edw. S., Brookline, Mass. (29). Born in Boston, Mass., Nov. 20, 1827. Died in Brookline, Mass., Feb. 13, 1889.
- Phillips, John C., Boston, Mass. (29). Born in 1839. Died Mar. 1, 1885.
- Pliggot, A. Snowden, Baltimore, Md. (10).
- Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Born in England, June 12, 1826. Died Oct., 1886.
- Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.
- Plumb, Ovid, Salisbury, Conn. (9).
- Pope, Charles Alexander, St. Louis, Mo. (12). Born in Huntsville, Ala., March 15, 1818. Died in Paris, Mo., July 6, 1870.
- Porter, John Addison, New Haven, Conn. (14). Born in Catskill, N. Y., March 15, 1822. Died in New Haven, Conn., Aug. 25, 1866.
- Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.
- Pourtalès, Louis François de, Cambridge, Mass. (1). Born March 4, 1824. Died July 19, 1880.

- Pruyn, John Van Schaick Lansing, Albany, N. Y. (1). Born in Albany, N. Y., June 22, 1811. Died in Clifton Springs, N. Y., Nov. 21, 1877.
- Pugh, Evan, Centre Co., Pa. (14). Born Feb. 29, 1828. Died April 29, 1864.
- Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.
- Putnam, Mrs. Frederick Ward, Cambridge, Mass. (19). Born in Charlestown, Mass., Dec. 29, 1838. Died in Cambridge, Mass., March 10, 1879.
- Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.
- Read, Ezra, Terre Haute, Ind. (20). Died in 1877.
- Redfield, William C., New York, N. Y. (1). Born near Middletown, Conn., March 26, 1789. Died Feb. 12, 1857.
- Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.
- Robb, James, Fredericton, N. B. (4).
- Robinson, Coleman T., Buffalo, N. Y. (15). Born in Putnam Co., N. Y., in 1888. Died near Brewster's Station, N. Y., May 1, 1872.
- Rochester, Thomas Fortescue, Buffalo, N. Y. (35). Born Oct. 8, 1823. Died May 24, 1887.
- Rockwell, John Arnold, Norwich, Conn. (10). Born in Norwich, Conn., August 27, 1803. Died in Washington, D. C., February 10, 1861.
- Roeder, F. A., Cincinnati, Ohio (30).
- Rogers, Henry Darwin, Glasgow, Scotland (1). Born in Philadelphia, Pa. Aug. 1, 1808. Died in Glasgow, Scotland, May 29, 1866.
- Rogers, James Blythe, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 11, 1802. Died in Philadelphia, June 15, 1852.
- Rogers, Robert Emile, Philadelphia, Pa. (18). Born in Baltimore, Md., March 29, 1818. Died Sept. 6, 1884.
- Rogers, William Barton, Boston, Mass. (1). Born in Philadelphia, Pa., Dec. 7, 1804. Died in Boston, May 30, 1882.
- Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.
- Sager, Abram, Ann Arbor, Mich. (6). Born in Bethlehem, N. Y., Dec. 22, 1811. Died August 6, 1877.
- Sanders, Benjamin D., Wellsburg, W. Va. (19).
- Scammon, Jonathan Young, Chicago, Ill. (17). Born in Whitefield, Me., in 1812. Died in Chicago, Ill., March 17, 1890.
- Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.
- Schimpff, Robert D., Scranton, Pa. (36).
- Schley, William, New York, N. Y. (28). Died in 1882.
- Schram, Nicholas Hallock, Newburgh, N. Y. (33). Died in Newburgh, N. Y., aged 54 years, 1 month and 2 days.
- Scott, Joseph, Dunham, C. E. (11). Died in 1865.
- Seaman, Ezra Champion, Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 15, 1880.
- Senecal, L. A., Montreal, Can. (31).

- Senter, Harvey S., Aledo, Ill. (20). Died in 1875.
- Seward, William Henry, Auburn, N. Y. (1). Born in Florida, N. Y., May 16, 1801. Died in Auburn, N. Y., Oct. 10, 1872.
- Sheafer, Peter W., Pottsville, Pa. (4). Died March 26, 1891.
- Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.
- Sherwin, Thomas, Dedham, Mass. (11). Born in Westmoreland, N. H., March 26, 1799. Died in Dedham, Mass., July 28, 1869.
- Sill, Elisha N., Cuyahoga Falls, Ohio (6). Born in 1801. Died April 26, 1888.
- Silliman, Benjamin, New Haven, Conn. (1). Born in North Stratford, Conn., August 8, 1779. Died in New Haven, Conn., Nov. 22, 1864.
- Silliman, Benjamin, New Haven, Conn. (1). Born in New Haven, Conn., Dec. 4, 1816. Died Jan. 14, 1885.
- Simpson, Edward, Washington, D. C. (28). Born in New York, N. Y., March 8, 1824. Died in Washington, D. C., Dec. 1, 1888.
- Skinner, George, Kalida, Ohio (88).
- Skinner, John B., Buffalo, N. Y. (15). Died in 1871.
- Slack, J. H., Philadelphia, Pa. (12).
- Smith, Charles A., St. Louis, Mo. (27). Died in 1884.
- Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.
- Smith, Mrs. Erminnie Adelle, Jersey City, N. J. (25). Born April 26, 1836. Died June 9, 1886.
- Smith, John Lawrence, Louisville, Ky. (1). Born near Charleston, S. C., Dec. 17, 1818. Died Oct. 12, 1883.
- Smith, J. V., Cincinnati, Ohio (5).
- Smith, James Young, Providence, R. I. (9). Born in Groton, Conn., Sept. 15, 1809. Died March 26, 1876.
- Smith, Lyndon Arnold, Newark, N. J. (9). Born in Haverhill, N. H., November 11, 1795. Died in Newark, N. J., December 15, 1865.
- Snell, Ebenezer Strong, Amherst, Mass. (2). Born in North Brookfield, Mass., October 7, 1801. Died in Amherst, Mass., Sept., 1877.
- Sparks, Jared, Cambridge, Mass. (2). Born in Willington, Conn., May 10, 1819. Died in Cambridge, Mass., March 14, 1866.
- Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.
- Squier, Ephraim George, New York, N. Y. (18). Born in Bethlehem, N. Y., June 17, 1821. Died in Brooklyn, N. Y., April 17, 1888.
- Stearns, Josiah A., Boston, Mass. (29).
- Stearns, Silas, Pensacola, Fla. (28). Died Aug. 2, 1888.
- Steele, Joel Dorman, Elmira, N. Y. (33). Born in Lima, N. Y., May 14, 1836. Died May 25, 1886.
- Stevenson, James, Washington, D. C. (29). Born in Maysville, Ky., Dec. 24, 1840. Died in New York, N. Y., July 23, 1888.
- Stimpson, Wm., Chicago, Ill. (12). Born Feb. 14, 1832. Died May 26, 1872.
- Stone, Leander, Chicago, Ill. (32). Died April 2, 1888.
- Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

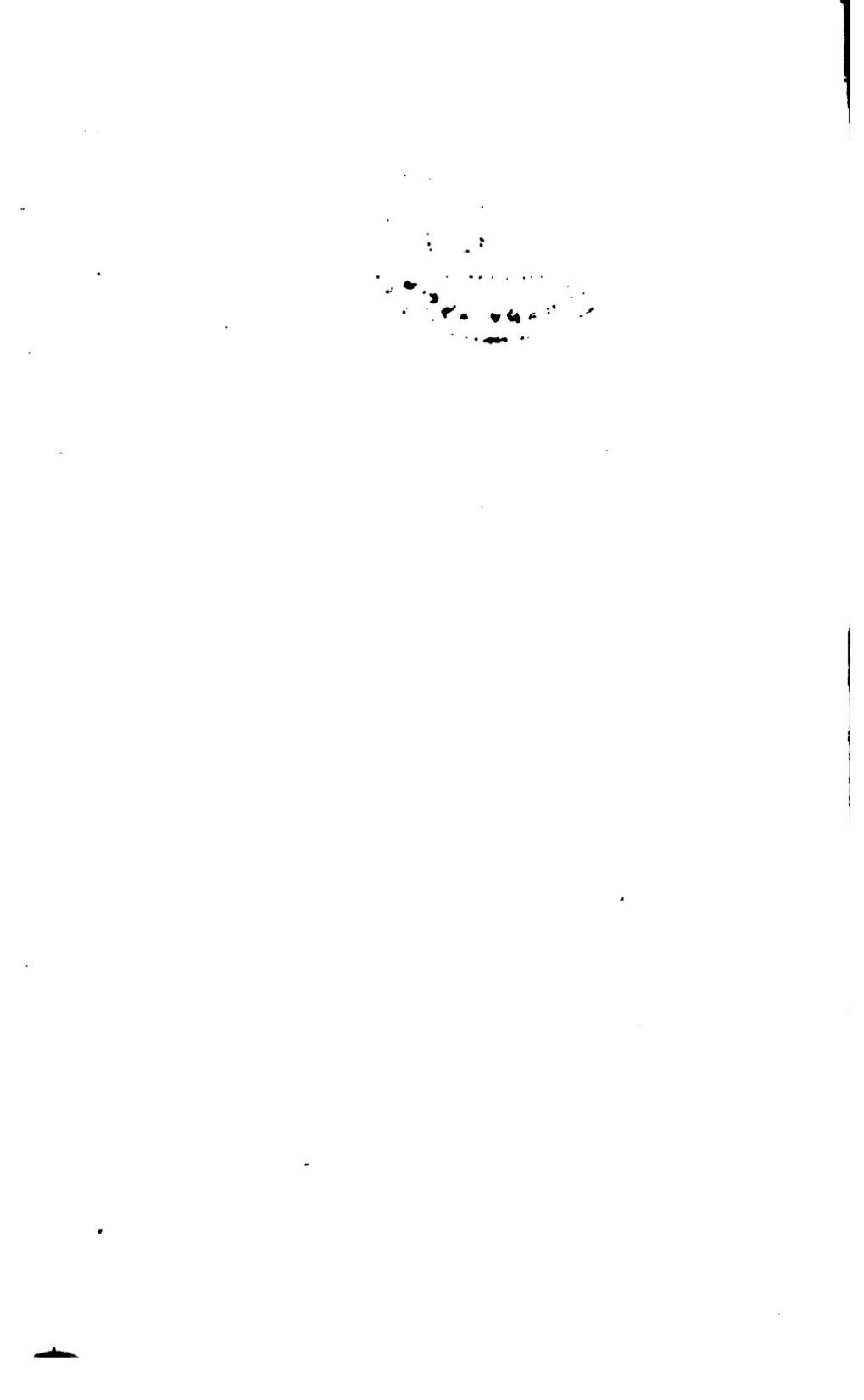
- St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.
Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.
Sturges, George, Chicago, Ill. (37). Born at Putnam, Ohio, May 13, 1838.
Died at Lake Geneva, Wis., Aug. 12, 1890.
Sullivan, Algernon Sidney, New York, N. Y. (36). Born April 5, 1826.
Died Dec. 4, 1887.
Sullivant, William Starling, Columbus, Ohio (7). Born near Columbus,
O., Jan 15, 1803. Died in Columbus, O., April 30, 1873.
Sutton, George, Aurora, Ind. (20.) Died June 18, 1886.
Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

- Tallmadge, James, New York, N. Y. (1). Born in Stamford, N. Y., Jan.
20, 1778. Died in New York, N. Y., Oct. 8, 1853.
Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died
June 28, 1883.
Taylor, Richard Cowling, Philadelphia, Pa. (1). Born in England, Jan.
18, 1789. Died in Philadelphia, Pa., November 26, 1851.
Taylor, Robert N., Tollesboro, Ky. (37). Died Aug. 13, 1888.
Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died
July 11, 1877.
Teschemacher, James Englehart, Boston, Mass. (1). Born in Notting-
ham, England, June 11, 1790. Died near Boston, Nov. 9, 1853.
Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.
Thompson, Alexander, Aurora, N. Y. (1).
Thompson, Charles Oliver, Terre Haute, Ind. (29). Born in East Windsor
Hill, Conn., Sept. 25, 1835. Died in Terre Haute, Ind., March 17, 1886.
Thompson, Zadock, Burlington, Vt. (1). Born in Bridgewater, Vt., May
23, 1796. Died in Burlington, Vt., Jan 19, 1856.
Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.
Thurber, Isaac, Providence, R. I. (9).
Tillemann, John Nicholas, Sandy, Utah (33). Born in Horhun, Denmark,
March 28, 1845. Died in Salt Lake City, Utah, Sept. 4, 1888.
Tillman, Samuel Dyer, Jersey City, N. J. (15). Born April, 1815. Died
Sept. 4, 1875.
Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1888.
Todd, Albert, St. Louis, Mo. (27). Born March 4, 1818. Died April
30, 1885.
Tolderoy, James B., Fredericton, N. B. (11).
Torrey, John, New York, N. Y. (1). Born in New York, N. Y., Aug. 15,
1796. Died in New York, March 10, 1873.
Torrey, Joseph, Burlington, Vt. (2). Born in Rowley, Mass., Feb. 2, 1797.
Died in Burlington, Vt., Nov. 26, 1867.
Totten, Joseph Gilbert, Washington, D. C. (1). Born in New Haven,
Conn., August 23, 1788. Died in Washington, D. C., April 22, 1864.
Townsend, Howard, Albany, N. Y. (10). Born Nov. 22, 1823. Died Jan.
6, 1867.

- Townsend, John Kirk, Philadelphia, Pa. (1). Born Aug. 10, 1809. Died Feb. 16, 1851.
- Townsend, Robert, Albany, N. Y. (9). Born 1799. Died Aug. 15, 1866.
- Trost, Gerard, Nashville, Tenn. (1). Born in Bois-le-Duc, Holland, March 15, 1776. Died in Nashville, Tenn., Aug. 14, 1850.
- Tuomey, Michael, Tuscaloosa, Ala. (1). Born in Ireland, September 29, 1805. Died in Tuscaloosa, Ala., March 20, 1857.
- Tweedale, John B., St. Thomas, Can. (35). Born in Ormskirk, Lancashire, Eng., Oct. 16, 1821. Died in St. Thomas, Can., Nov. 18, 1889.
- Tyler, Edward R., New Haven, Conn. (1). Born Aug. 8, 1800. Died Sept. 28, 1848.
- Vancleve, John W., Dayton, Ohio (1).
- Vanuxem, Lardner, Bristol, Pa. (1). Born in Philadelphia, Pa., July 23, 1792. Died in Bristol, Pa., June 25, 1848.
- Vaux, William Sanson, Philadelphia, Pa. (1). Born in Philadelphia, May 19, 1811. Died in Philadelphia, May 5, 1882.
- Wadsworth, James Samuel, Genesee, N. Y. (2). Born in Geneseo, N. Y., October 30, 1807. Died near Chancellorsville, Va., May 8, 1864.
- Wagner, Tobias, Philadelphia, Pa. (9).
- Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.
- Walker, Joseph, Oxford, N. Y. (10).
- Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.
- Walker, Timothy, Cincinnati, Ohio (4). Born in Wilmington, Mass., Dec. 1, 1802. Died in Cincinnati, Ohio, Jan. 15, 1856.
- Walling, H. F., Cambridge, Mass. (16). Died April 8, 1888.
- Walsh, Benjamin D., Rock Island, Ill. (17). Born in Frome, England, Sept. 21, 1808. Died in Rock Island, Ill., Nov. 18, 1869.
- Walton, Joseph J., Philadelphia, Pa. (29). Born in Barnesville, Ohio, Nov. 1, 1855. Died in Philadelphia, Pa., Oct. 11, 1889.
- Wanzer, Ira, Brookfield, Conn. (18). Born in New Fairfield, Conn., April 17, 1796. Died in New Milford, Conn., March 5, 1879.
- Warnecke, Carl, Montreal, Can. (81). Died May 14, 1886.
- Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.
- Warren, Gouverneur Kemble, Newport, R. I. (12). Born in Cold Spring N. Y., Jan. 8, 1830. Died in Newport, R. I., Aug. 8, 1882.
- Warren, John Collins, Boston, Mass. (1). Born in Boston, Mass., Aug. 1, 1778. Died in Boston, May 4, 1856.
- Warren, Samuel D., Boston, Mass. (29). Born in 1817. Died May 11, 1888.
- Watertown, Charles, Wakefield, Eng. (1). Born in Wakefield, England. Died in Wakefield, May 26, 1865.
- Watkins, Samuel, Nashville, Tenn. (26).
- Watson, James Craig, Ann Arbor, Mich. (18). Born in Fingal, Canada, Jan. 28, 1838. Died in Madison, Wis., Nov. 28, 1880.

- Webster, Horace B., Albany, N. Y. (1). Born in 1812. Died Dec. 8, 1843.
Webster, J. W., Cambridge, Mass. (1). Born in 1793. Died Aug. 80, 1850.
Webster, M. H., Albany, N. Y. (1).
Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.
Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.
Welsh, John, Philadelphia, Pa. (38). Died May, 1886.
Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.
Wheatland, Richard H., Salem, Mass. (18). Born July 6, 1830. Died Dec. 21, 1863.
Wheatley, Charles M., Phoenixville, Pa. (1). Died May 6, 1882.
Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.
Whitall, Henry, Camden, N. J. (38).
White, Samuel S., Philadelphia, Pa. (28). Died Dec. 30, 1879.
Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.
Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.
Whitman, Wm. E., Philadelphia, Pa. (28). Died in 1875.
Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.
Whittlesey, Charles, Cleveland, Ohio (1). Born in Southington, Conn., Oct. 5, 1808. Died Oct. 18, 1886.
Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.
Wight, Orlando W., Detroit, Mich. (34).
Wilber, G. M., Pine Plains, N. Y. (19).
Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.
Willard, Emma C. Hart, Troy, N. Y. (15). Born in Berlin, Conn., Feb. 23, 1787. Died in Troy, N. Y., April 15, 1870.
Williams, Frank, Buffalo, N. Y. (25). Died Aug. 18, 1884.
Williams, P. O., Watertown, N. Y. (24).
Williamson, Robert S., San Francisco, Cal. (12). Born in New York about 1825.
Wilson, C. H., Belize, British Honduras (30).
Wilson, Mrs. Mary V. C., Mobile, Ala. (37). Born in Morengo County, Ala., Jan. 29, 1840. Died near Tullahoma, Tenn., June 24, 1889.
Wilson, W. C., Carlisle, Pa. (12).
Winchell, Alexander, Ann Arbor, Mich. (3). Born in North East, N. J., Dec. 31, 1824. Died in Ann Arbor, Mich., Feb. 19, 1891.
Winlock, Joseph, Cambridge, Mass. (5). Born in Shelbyville, Ky., Feb. 6, 1826. Died in Cambridge, Mass., June 11, 1875.
Woerd, Chas. Vander, Waltham, Mass. (29). Born in Leyden, Holland, Oct. 6, 1821. Died near Dagget, Cal., Dec. 29, 1888.
Woodbury, Levi, Portsmouth, N. H. (1). Born in Francistown, N. H., Dec. 22, 1789. Died Sept. 4, 1851.
Woodman, John Smith, Hanover, N. H. (11). Born in Durham, N. H., Sept. 6, 1819. Died in Durham, N. H., May 15, 1871.

- Woodward, Joseph Janvier, Washington, D. C. (28). Born in Philadelphia, Pa., Oct. 30, 1883. Died near that city, Aug. 17, 1884.
- Worthen, Amos Henry, Springfield, Ill. (5). Born Oct. 31, 1813. Died May 6, 1888.
- Wright, Elizur, Boston, Mass. (81). Born in South Canaan, Conn., Feb. 12, 1804 Died Nov. 20, 1885.
- Wright, Harrison, Wilkes Barre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.
- Wright, John, Troy, N. Y. (1).
- Wyman, Jeffries, Cambridge, Mass. (1). Born in Chelmsford, Mass., Aug. 11, 1814. Died in Bethlehem, N. H., Sept. 4, 1874.
- Wyckoff, William Cornelius, New York, N. Y. (20). Born in New York, N. Y., May 28, 1832. Died in Brooklyn, N. Y., May 2, 1888.
- Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.
- Youmans, Edward Livingston, New York, N. Y. (6). Born in Coeymans, N. Y., June 8, 1821. Died Jan. 18, 1887.
- Young, Ira, Hanover, N. H. (1). Born in Lebanon, N. H., May 23, 1801. Died in Hanover, N. H., Sept. 14, 1858.
- Zentmayer, Joseph, Philadelphia, Pa. (29). Died, 1887.





ADDRESS

BY

T. C. MENDENHALL,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

***THE RELATIONS OF MEN OF SCIENCE TO THE GENERAL
PUBLIC.***

JUST fifty years have passed since a small body of enthusiastic students of Geology and Natural History organized themselves into an Association which was, for the first time in the history of this country, not local in its membership or in its purpose. As the "Association of American Geologists and Naturalists," it was intended to include any and all persons, from any and all parts of the country, who were actively engaged in the promotion of Natural History studies and who were willing to re-inforce and strengthen each other by this union. So gratifying was the success of this undertaking that after a few years of increasing prosperity under its first name, the Association wisely determined to widen the field of its operations by resolving itself into the American Association for the Advancement of Science, thus assuming to be in title what it had really been in fact, from the beginning of its existence. One of the articles of its first constitution, adopted at its first meeting, provided that it should be the duty of its president to present an address at a General Session following that over which he presided. The performance of this duty cannot, therefore, be easily avoided by one who has been honored by his fellow members in being called upon to preside over the deliberations of this Associa-

ation ; nor can it be lightly disposed of when one realizes the importance of the occasion and recalls the long list of his distinguished predecessors, each of whom in his turn has brought to this hour at least a small measure of the work of a lifetime devoted to the interests of science.

The occasion is one which offers an opportunity and imposes an obligation. The opportunity is in many ways unique and the obligation is correspondingly great. In the delivery of this address the retiring president usually finds himself in the presence of a goodly number of intelligent people, representatives of the general public who, knowing something of the results of scientific investigation, have little idea of its methods, and whose interest in our proceedings, while entirely cordial and friendly, is often born of curiosity rather than a full appreciation of their value and importance. Mingled with them are the Members and Fellows of the Association who have come to the annual gathering laden with the products of many fields which they have industriously cultivated during the year ; each ready to submit his contribution to the inspection and criticism of his comrades and all hoping to add in some degree to the sum total of human knowledge.

The united presence of these two classes intensifies the interest which naturally attaches to an occasion like this and not unnaturally suggests that a brief consideration of the relations which do exist and which should exist between them may afford a profitable occupation for us this evening.

In the beginning it may be truthfully affirmed that no other single agency has done as much to establish these relations on a proper basis as the American Association for the Advancement of Science. In the first article of its constitution the objects of the Association are defined as follows :— “ by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States, to give a stronger and more general impulse and a more systematic direction to scientific research in our country, and to procure for the labors of scientific men, increased facilities and a wider usefulness.” So perfectly do these words embody the spirit of the Association that when more than thirty years later the constitution was thoroughly revised, none better could be found to give it expression. That it has been successful in promoting intercourse between those who are cultivating science in different parts of the United States may.

be proved by the testimony of thousands who have come to know each other through attendance at its meetings. In a country whose geographical limits are so extensive as ours and whose scientific men are so widely scattered, it is difficult to overestimate its value in this particular.

In giving a stronger and more general impulse and a more systematic direction to scientific research in our country it has been singularly fortunate. Its meetings have been the means of disseminating proper methods of investigation and study throughout the land; hundreds of young students, enthusiastic but often not well trained, have found themselves welcome (sometimes to their own astonishment), and by its influence and encouragement have been moulded and guided in the utilization of their endowments, occasionally exceptional, to the end that they have finally won a fame and renown which must always be treasured by the Association as among its richest possessions. Wherever its migratory meetings have been held the pulse of intelligence has been quickened, local institutions have been encouraged and strengthened, or created where they did not before exist, and men of science have been brought into closer relations with an intelligent public.

But it is in relation to the last of the three great objects, to accomplish which the Association was organized, namely, "to procure for the labors of scientific men increased facilities and a wider usefulness" that it has been, on the whole, less successful. It is true that when we look at the history of science in America during the past fifty years; when we see at every point evidences of public appreciation, or at least appropriation of scientific discovery; and most of all, when we observe the enlargement of older institutions of learning to make room for instruction in science, and the generous donations to found new technical and scientific schools together with an occasional endowment of research, pure and simple; in view of all these, I say, we are almost constrained to believe that scientific men have only to ask, that their facilities may be increased and that their labors could hardly have a wider usefulness.

Unfortunately this pleasing picture is not a true reflection of the actual condition of things. The attentive observer cannot fail to discover that the relation between men of science and the general public is not what it should be in the best interests of either or both. In assemblages of the former it is common to hear com-

plaints of a lack of appreciation and proper support on the part of the latter, from whom, in turn, occasionally comes an expression of indifference, now and then tintured with contempt for men who devote their lives and energies to study and research, the results of which cannot always be readily converted into real estate or other forms of taxable property. It cannot be denied that the man of science is at some disadvantage as compared with his neighbor, the successful lawyer or physician, when it comes to that distribution of confidence with responsibility which usually exists in any well ordered community, although the latter may possess but a fraction of the intellectual power and sound judgment which he can command. To his credit it may be said that he is usually considered to be a harmless creature and to render him assistance and encouragement is generally regarded as a virtue. The fact of his knowing much about things which do not greatly concern the general public is accepted as proof that he knows little of matters which seriously affect the public welfare.

It is true that when the public is driven to extremities it sometimes voluntarily calls upon the man of science, and in this emergency it is often unpleasantly confronted with the fact that it does not know where to find him. The scientific dilettante, or worse, the charlatan is often much nearer the public than the genuine man of science and the inability to discriminate sometimes results in disaster in which both science and the public suffer.

In venturing to suggest some possible remedies for this condition of things it will be logical, if not important, to roughly define the two classes under consideration, the scientific and the non-scientific. One is the great majority, the general public, including in the United States over sixty millions of people in all conditions, cultured and uncultured, educated and uneducated, but in average intelligence, we are proud to say, superior to the people of any other nation in the world. Out of these it is not easy to sift by definition, the small minority properly known as men of science. Only a rough approximation may be reached by an examination of the membership of scientific societies.

The American Association for the Advancement of Science includes in its membership about two thousand persons. It is well known, however, that many of these are not actually engaged in scientific pursuits, either professionally or otherwise; indeed it is one of the important functions of the society to gather into its fold

as many of this class as possible. The fellowship of the association is limited however, by its constitution, to such members as are professionally engaged in science, or have by their labors aided in advancing science. They number about seven hundred, but in this case it is equally well known that the list falls far short of including all Americans who by their labors in science are justly entitled to a place in any roll of scientific men. On the whole, it would not, perhaps, be a gross exaggeration to say that not more than one in fifty thousand of our population could be properly placed upon the list, even with a liberal interpretation of terms.

In this estimate it is not intended, of course, to include that large class of active workers whose energies are devoted to the advancement of applied science. Although their methods are often the result of scientific training, and while the solution of their problems requires much knowledge of science, the real advancement of science at their hands is rather incidental than otherwise. In certain particulars they may be likened to the class known as "middle men" in commercial transactions, the connecting link between producer and consumer. It is in no way to their discredit that they usually excel both of these, in vigilance and circumspection and in their quick perception of utility. By them the discoveries of science are prepared for and placed upon the market, and it is difficult to overestimate their usefulness in this capacity. It is true that the lion's share of the profit in the transaction is generally theirs and that they are often negligent in the matter of giving the philosopher the credit to which he is entitled, but for the latter, at least, it is believed that the philosopher is himself often responsible.

If this statement of the relative numbers of the scientific and the non-scientific is reasonably correct, the scientific man may at least congratulate himself on wielding an influence in affairs vastly greater than the census, alone, would justify, and this fact encourages the belief that if there is anything "out of joint" in his relations with the general public, the remedy is in his own hands. Let our first inquiry be, then, in what particulars does he fail in the full discharge of his duties as a man of science and especially as an exponent of science among his fellows?

Without attempting to arrange the answers which suggest themselves in logical order or, indeed, to select those of the first importance, I submit, to begin with, his inability or unwillingness,

common but by no means universal, to present the results of his labors in a form intelligible to intelligent people. When inability, it is a misfortune, often the outgrowth, however, of negligence or indifference; when unwillingness, it becomes at least an offence, and one not indicative of the true scientific spirit. Unfortunately we are not yet entirely out of the shadow of the middle ages, when learning was a mystery to all except a select few, or of the centuries a little later, when a scientific treatise must be entombed in a dead language or a scientific discovery embalmed in a cipher.

Many scientific men of excellent reputation are to-day guilty of the crime of unnecessary and often premeditated and deliberately planned mystification; in fact almost by common consent this fault is overlooked in men of distinguished ability if, indeed, it does not add a lustre to the brilliancy of their attainments. It is usually regarded as a high compliment to say of A that when he read his paper in the mathematical section, no one present was able to understand what it was about; or of B and his book that there are only three men in the world who can read it. We greatly, though silently admire A and B while C the unknown, who has not yet won a reputation and who ventures to discuss something which we do understand (after his clear and logical presentation of the subject) must go content with the patronizing admonition that there is really nothing new about this, and that if he will consult the pages of a certain journal of a few years ago he will find the same idea, not developed, it is true, but hinted at and put aside for future consideration, or that he will find that Newton or Darwin declared what is essentially the same principle many years before. No one can deny that there is great reason and good judgment displayed in all this, but the ordinary layman is likely to inquire whether it is distributed and apportioned with nice discrimination; and it is the standpoint of the layman which we are occupying at the present moment.

All will admit that there are many men whose power in original thinking and profound research is far greater than their facility of expression, just as on the other hand, there are many more men whose linguistic fluency is unembarrassed by intellectual activity, and representatives of both classes may be found among those usually counted as men of science. It is with the first only that we are concerned at the present moment, and it is sufficient to remark that their fault is relatively unimportant and easily overlooked.

Among them is often found that highly prized but imperfectly defined individual known as the "genius," for whose existence we are always thankful, even though his interpretation is difficult and laborious.

Concerning those who, although able, are unwilling to take the trouble to write for their readers or speak for their hearers, a somewhat extended comment may be desirable. It is always difficult to make a just analysis of motives, but there can be little doubt that some of these are influenced by a desire to imitate the rare genius whose intellectual advances are so rapid and so powerful as to forbid all efforts to secure a clear and simple presentation of results. The king is lame and the courtier must limp. With others there is a strange and unwholesome prejudice against making science intelligible for fear that science may become popular. It is forgotten that clear and accurate thinking is generally accompanied by the power of clear, concise and accurate expression, and that as a matter of fact the two are *almost* inseparable. The apparent success before the people of the dilettante and the charlatan has resulted, in the case of many good and able men, in a positive aversion to popular approval. It should never be forgotten that the judgment and taste of the public in matters relating to science are just as susceptible of cultivation as in music and the fine arts, and that scientific men owe it to themselves to see that opportunity for this culture is not withheld. A just appreciation by the people of real merit in art has resulted in the production of great painters, sculptors, musicians and composers, and there is every reason to believe that the best interests of science would be fostered by similar treatment. Even the great masters in science, then, can well afford to do what is in their power to popularize their work and that of their colleagues so that through closer relations with a more appreciative public their opportunities may be enlarged and their numbers increased.

Another error into which the man of science is liable to fall is that of assuming superior wisdom as regards subjects outside of his own specialty. It may seem a little hard to accuse him of this, but nevertheless, it is a mistake into which he is easily and often unconsciously led. That this is the day of specialization and specialists every student of science learns at the very threshold of his career; but that one man can be expected to be good authority on not more than one or two subjects, is not so generally understood

by the public. It thus frequently happens that the man of science is consulted on all matters of a scientific nature and he is induced to give opinions on subjects only remotely, if at all, related to that branch of science in which he is justly recognized as an authority. Although going well for a time, these opinions often prove to be erroneous in the end, resulting in a diminution of that confidence which the public is, on the whole, inclined to place in the dictum of science.

Examples of this condition of things are by no means wanting, and they are not confined, as might at first be assumed, to the lower ranks of science. A distinguished botanist is consulted and advises concerning the location of the natural gas field; a mathematician advises a company in which he is a stockholder in regard to the best locality for boring for oil, and a celebrated biologist examines and makes public report upon a much-talked-of invention in which the principles of physics and engineering are alone involved.

In these and many other instances which might be related, the motives of those concerned, at least on one side of the transaction, cannot be questioned, but certainly their judgment is open to criticism and the outcome of it all, is that the confidence of the people in scientific methods and results is weakened. Fifty years ago or a hundred years ago, there was good reason for much of this sort of thing. Specialization was neither as possible nor as necessary as now; the sparseness of the population of the country, the absence of centres of learning and scientific research, the obstacles in the way of easy and rapid communication between different parts of the country, all these and other circumstances contributed to the possibility of a Franklin, who wrote and wrote well upon nearly all subjects of human thought; whose advice was sought and given in matters relating to all departments of science, literature and art. Combining in an extraordinary degree the power of profound research with a singularly simple and clear style in composition, together with a modesty which is nearly always characteristic of the genuine student of nature, he wisely ventured further than most men would dare to-day, in the range of topics concerning which he spoke with authority.

But at the present time and under existing conditions there is little excuse for unsupported assumption of knowledge by men of science, and, fortunately, the danger of humiliating exposure is

correspondingly great. The specialist is everywhere within easy reach, and the expression of opinions concerning things of which one knows but little is equally prejudicial to the interests of science and society.

The scientific man should also be at least reasonably free from egotism in matters relating to his own specialty and particularly in reference to his own authority and attainments therein. In controversy he has the advantage over most disputants in that he can usually call to his support an unerring and incontrovertible witness. A well conducted experiment or an exhaustive investigation carried out with scrupulous honesty, deservedly carries great weight, but it must not be forgotten that it does not, in a very great degree, depend upon the personality of him who directs the experiment or plans the investigation. One must not confound himself and his work, to the extent of assuming that upon him ought to be bestowed the praise and admiration to which his work is, perhaps, justly entitled. This blunder is analogous to that of the mechanic in whom the first symptom of insanity appeared as a conviction that he was as strong as the engine which he had built, evidence of which he unpleasantly thrust upon any who might deny the truth of his assertion. "By your works shall ye be judged" may be especially affirmed of men of science not only as regards the judgment of the public, but particularly that of their colleagues and fellow-workers. Least of all should title, degree, membership in learned societies or the possession of medals or other awards of distinction and honor, be paraded unduly, or offered by himself, in evidence of his own fitness. In general these are honorable rewards which are justly prized by scientific men, but some of them have been so indiscriminately bestowed and, in some instances, falsely assumed that the general public, not yet properly educated in this direction, does not attach great value to them as an index of real scientific merit. Where real merit actually exists, nothing is usually gained and much is likely to be lost by boastful announcements of high standing or of accumulated honor. A distinguished man of science at the end of a controversy into which he had been called as such, complained that he had not been recognized as a Fellow of the Royal Society. "You gave us no reason to suspect your membership," quietly, but severely, replied a man of the world.

As another element of weakness in the scientific man I venture

to suggest that he is often less of a utilitarian than he should be. This is a sin, if it be such, which seems especially attached to those who, unconsciously or otherwise, are imitators of men of science of the highest type. The latter are so entirely absorbed in profound investigation and their horizon is necessarily so limited by the very nature of the operations in which they are engaged, that they are altogether unlikely to consider questions of utility nor, indeed, is it desirable that they should. The evolution of processes and methods by means of which the complex existence of the present day is maintained, is largely the result of specialization or the division of labor. In such a scheme there is room for those who never demand more of a fact than that it be a fact; of truth that it be truth. But even among scientific men the number of such is small and as a class they can never be very closely in touch with the people.

Strong to imitate, even in those characteristics which are akin to weakness, many persons of lesser note affect a contempt for the useful and the practical which does not tend to exalt the scientific man in the opinion of the public. Even the great leaders in science have been misrepresented in this matter. Because they wisely determined in many instances to leave to others the task of developing the practical applications of their discoveries, it has often been represented that they held such applications as unworthy a true man of science. As illustrating the injustice of such an opinion one may cite the case of the most brilliant philosopher of his time, Michael Faraday, who in the matter of his connection with the Trinity House alone, gave many of the best years of his life to the service of his fellow-men. The intensely "practical" nature of this service is shown by the fact that it included the ventilation of light-houses, the arrangement of their lightning conductors, reports upon various propositions regarding lights, the examination of their optical apparatus and testing samples of cotton, oils and paints. A precisely similar illustration is to be found in the life of our own great physicist, Joseph Henry, who sacrificed a career as a scientific man, already of exceptional brilliancy, yet promising a future of still greater splendor, for a life of unselfish usefulness to science and to his countrymen as Secretary of the Smithsonian Institution, as a member of the Light House Board and in other capacities for which he was especially fitted by nature as well as by his scientific training.

There is an unfortunate, and perhaps a growing tendency among scientific men to despise the useful and the practical in science, and it finds expression in the by no means uncommon feeling of offended dignity when an innocent layman asks what is the use of some new discovery?

Referring to the theoretically extremely interesting spar prism of Bertrand, which under certain conditions may be used to detect traces of polarization of light, a recent writer remarks, "But for this application the prism would possess, in the eyes of the true votary of science, the inestimable value of being of no practical utility whatever."

Much is said, everywhere and at all times, about the pursuit of science for the sake of science, and on every hand it is sought to convey the impression that one who has any other object in view in interrogating Nature than the mere pleasure of listening to her replies, is unworthy of a high place among men of science. So old, so universally accepted, so orthodox, is this proposition, that it is with much hesitation that its truth is questioned in this presence. In so far as it means that one cannot do anything well unless it is done *con amore*, that pecuniary reward alone will never develop genius, that no great philosopher, or poet or artist will ever be other than unselfishly devoted to and in love with his work, just so far it is true, although it does not, as is often assumed, furnish a motive of the highest order. It is a trite saying, but perhaps it cannot be too often repeated, that he who lives and labors in the interest of his fellows that their lives may be brightened, that their burdens may be lessened, is above all others worthy of the highest praise. By this standard, the value of a discovery must at last be fixed, bearing in mind, of course, that the physical comfort of man is not alone to be considered. Judged by this standard, the work of Newton, of Watt, of Franklin, Rumford, Faraday, Henry and a host of others is truly great. There should be, and there usually is, no controversy as to relative merit between the discoverer of a gem and the artist who polishes and sets it. In science, the genius of the former is unquestionably rarer and of a higher order, but his work will always be incomplete and in a great degree useless until supplemented by that of the latter.

Another demand which the public may justly make upon the man of science is that his interest in public affairs should not be less than that of other men. Through his failure in this particular, sci-

ence has long suffered and is suffering in an increasing degree. This criticism is especially applicable in this country, where in theory every man is supposed to bear his share of the public burden, and to take his part in the performance of public duties. Unfortunately the attitude of the scientific man is too often one of criticism and complaint concerning matters in the disposition of which he persistently declines to interfere. It cannot be denied, I think, that men well trained in the logic and methods of scientific research, ought to be exceptionally well equipped for the performance of certain public duties constantly arising out of local, state or national legislation ; yet the impression is well-nigh universal, that the scientific man has no genius for "affairs." Indeed it has been more than once affirmed that he is utterly devoid of administrative or executive ability, and even that he cannot be trusted with the direction of operations which are almost wholly scientific in their nature. That there are many examples which seem to justify this belief is too true, but that there are other instances in which administrative and scientific ability have been combined is also true. Little search is required to reveal cases in which men of science have so ignored all ordinary rules and maxims of business procedure as to merit severe criticism, in which, unfortunately, the public does not discriminate between the individual and the class which he represents. It seems astonishing that one who is capable of successfully planning and executing an elaborate research, in which all contingencies are provided for, the unexpected anticipated and all weak points guarded and protected, may utterly break down in the management of some much less complicated business affair, such as the erection of a laboratory or the planning of an expedition, and I am unwilling to believe that such failures are due to anything other than culpable negligence on the part of the individual.

It is generally recognized that, aside from all questions of a partisan political nature, this country is to-day confronted by several problems of the utmost importance to its welfare, to the proper solution of which the highest intellectual powers of the nation should be given. The computation of the trajectory of a planet is a far easier task than forecasting the true policy of a great republic, but those qualities of the human intellect which have made the first possible should not be allowed to remain idle while an intelligent public is striving to attain the last. That men of science have not,

thus far, made their full contribution to the solution of some of these great problems is due to the fact that many have exhibited an inexcusable apathy towards everything relating to the public welfare, while others have not approached the subject with that breadth of preparation in the close study of human affairs which is necessary to establish the authenticity of their equations of condition. As already intimated, we do not seem to be getting on in this direction. Our own early history and the history of other nations is full of examples of eminent scientific men who were no less distinguished as publicists and statesmen. The name of Franklin is imperishable alike in the history of science and of politics. On many questions relating to exact science, the Adamses spoke with confidence; Thomas Jefferson was a philosopher, and on assuming the duties of the highest office in the gift of the people, counted his opportunities for association with men of science as one of its chiefest rewards. Other illustrations might be selected from the pages of the history of our own country, while in Europe, where science has been longer cultivated and under more favorable conditions, they are much more common. This is notably so in France, whose roll of scientific men, who have distinguished themselves and their country during the past century, includes many names prominent alike for the importance of their performance in her various crises of peace and war. The present president of the French Republic, himself an engineer, bears a name made famous in the history of science by the rich contributions of his ancestors, one of whom voted for the execution of Louis XVI, and was a member of the Committee of Public Safety. It would be difficult to overestimate the value to science as well as to the public, of the presence in the halls of legislation of even a very small number of men who might stand as exponents of the methods of science and as competent authorities on the results of their application. Our national congress, especially, is almost constantly dealing with questions of great moment to the people, which can only be thoroughly understood and wisely dealt with by scientific men, and the presence of one or two such in each branch of that body would be of decided advantage to the whole country. In the nature of things, opportunities for such representation will be rare, but when they occur they must not be suffered to escape.

Finally, if the conclusions reached in the foregoing should be thought wise, and should any young man at the threshold of his

scientific career determine to be guided by them in establishing his relations with the general public, he will find splendid examples among the distinguished leaders of all departments of science. Should he desire to present the results of his labors in such a way that they may be understood by intelligent people, he may imitate Franklin, whose literary style, as to simplicity and clearness, commanded the highest praise from literary men; or Faraday, who was able to give expression to the most involved conceptions in simple English; or Tyndall, the appearance of whose "Heat considered as a Mode of Motion," was an epoch in the history of Physical Science, in its relation to an intelligent constituency, without which it cannot thrive. He will learn that there is no discredit in "popularizing" science; that popularizing what is not science is the thing that is to be shunned and prevented. The arrogance of genius is not less disagreeable than that of riches, although it is less common.

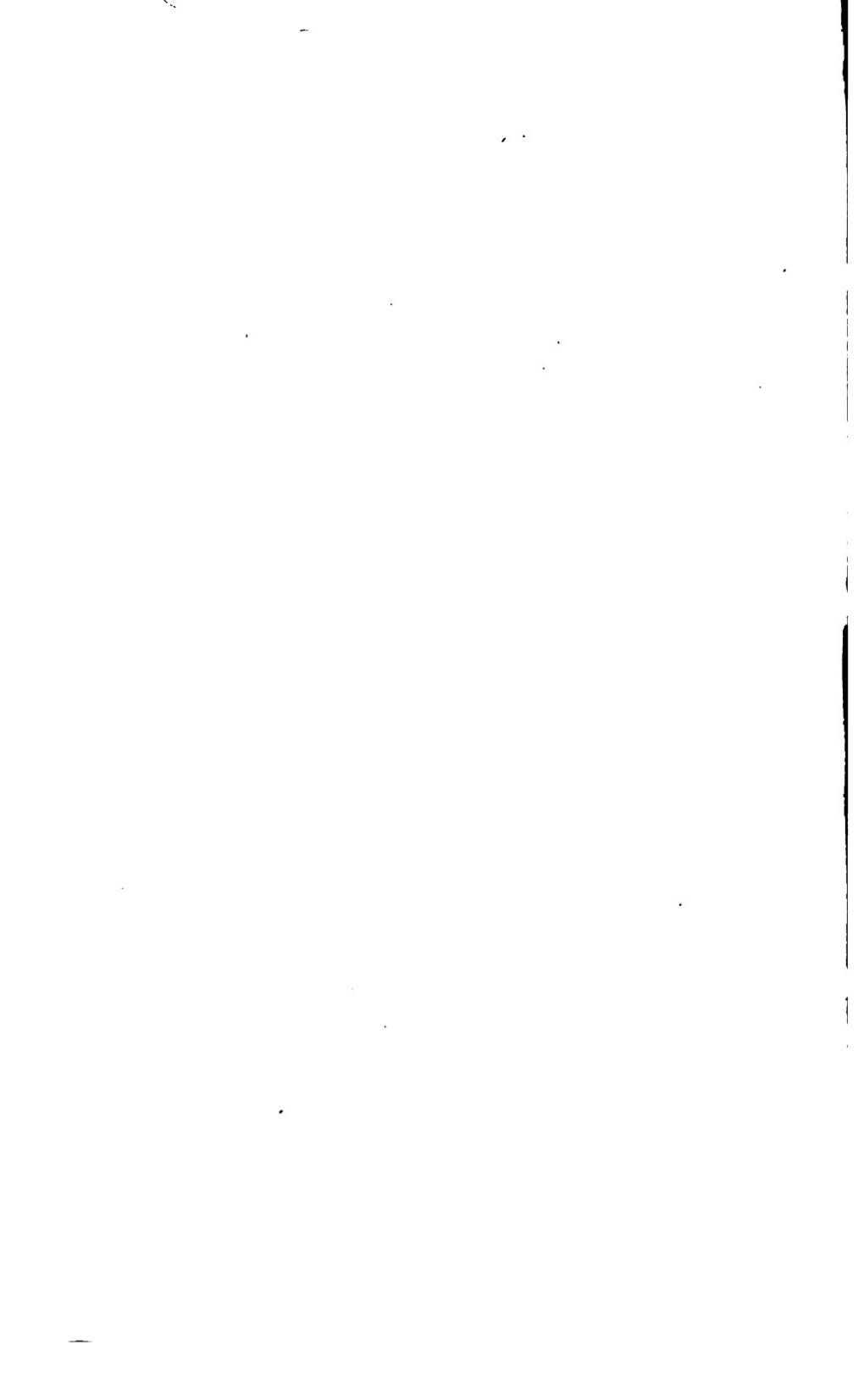
Should he wish to cultivate modesty in estimating his own attainments, he need only follow Newton, Darwin, and, in fact, the whole list of distinguished men of science down to the present time, with a few rare and unexplainable exceptions, the existence of which serves, like a whistling buoy, to point out what should be avoided.

Should he aspire to be of some use to the world and to leave it better because of his life, he will be encouraged by the fact, already considered, that in the long run those discoveries are most highly esteemed, and justly so, which are the most potent in their influence upon civilization and society by ameliorating the condition of the people, or by enlarging their opportunities, and that all really great men of science have not lost sight of this fact: that "science for the sake of science" does not represent the highest ideal, nor can the "almighty dollar" ever be bartered for the "Divine Aflatus."

All of these questions will serve to enlarge his interest in public affairs, because he will come to recognize that he is himself but a part of the public. He will remember the delight of Faraday, when near the end of his life he saw a huge dynamo illuminating the tower of a light-house. That which he had given to the world as an infant, in his splendid discovery of induction, had, through the fostering care of others, grown to a brilliant manhood, and he experienced exquisite pleasure in the reflection that it might be the means of saving the lives of his fellow men. The ideal of duty

which ought to be present in the mind of every man of science may well be higher than that growing out of mere selfish pleasure in the acquisition and possession of knowledge.

Perhaps it is hardly becoming in me, at this time and in some sense representing this large body of scientific men, to make even a simple remark in criticism of the general public, the party of the second part in the question which we have considered to-night. I venture to suggest, however, that whenever the public is disposed to consider its obligations to science and her votaries, there are some things which must not be forgotten ;—things so important and so numerous, indeed, that many volumes would be inadequate to their enumeration. Prove this by comparing the world *with* science with the world *without* science. Take as an illustration that which less than two hundred years ago was but a spark, a faint spark, exhibited on rare occasions by the scientific man of that time. With this spark, thanks to science, the whole world is now aflame. Time and space are practically annihilated ; night is turned into day ; social life is almost revolutionized and scores of things which only a few years ago would have been pronounced impossible, are being accomplished daily. Many millions of dollars of capital and many thousands of men are engaged in the development of this agent, so purely a creation of science that the Supreme Court of the land has already decided that it has no material existence. Surely science, which has brought us all these blessings, together with thousands besides, is worthy of every care and consideration at the hands of a generous and appreciative public.



REPORTS OF COMMITTEES.

REPORT OF COMMITTEE ON THE INTERNATIONAL CONGRESS OF GEOLOGISTS.

August 16, 1890.

*American Committee on the International Congress of Geologists
to the American Association for the Advancement of Science.*

GENTLEMEN:

SINCE the last meeting of the A. A. A. S. in Toronto, when a report from this committee was received and the committee continued, it has held one regular meeting in the city of New York on the evening of December 26, 1889.

The report of the Secretary having shown that the geological map of Europe was to be issued in sheets as fast as completed instead of as a whole when all the sheets had been finished, the committee decided to send the communication of which the translation follows to Professor Hauchecorne the active member of the executive committee on the map.

Dec. 26, 1890.

HONORED SIR:

The most important duty which falls to the lot of the American Committee is to perfect the method to be pursued in distributing the one hundred copies of the geological map of Europe, which according to the decision at London are to be assigned to the committee's countrymen.

This map will be of absolute necessity to our institutions of learning and geologists, and at the same time it will be very difficult, without a previous understanding with Dr. Beyrich and yourself, to accomplish this distribution. If you will accept the proposition of our Secretary, Dr. Frazer, and will send the sheets as published, directly to the American subscribers, we will do our utmost to lighten your labor. In any case there is much that must be discussed with the Treasury Department here and this can only be done after we have had information from you.

Have any sheets been already published and delivered to the European subscribers?

We beg you to inform Dr. Frazer of your wishes and remain with very great respect
(Signed)

JAMES HALL, President.

T. STERRY HUNT.

E. D. COPE.

J. J. STEVENSON.

C. H. HITCHCOCK.

H. S. WILLIAMS.

E. A. SMITH.

PERSIFOR FRAZER, Secretary.

The above letter was registered in the Philadelphia Post Office, and the notice of its receipt by the addressee was given through the same office, but up to the present time no reply has been received.

This committee proceeded to fill the vacancies in the list of its members caused by the resignation of Sir J. W. Dawson and Maj. J. W. Powell and the death of Prof. G. H. Cook.

Ballots having been taken for this purpose, Dr. Robert Bell of Ottawa was elected to fill the vacancy caused by the resignation of Sir J. W. Dawson; Mr. C. D. Walcott, U. S. G. S., was elected to fill the vacancy caused by the resignation of Major Powell and Prof. Wm. B. Scott, of the University of N. J., was elected to take the place of Prof. G. H. Cook, Director of the N. J. G. S., deceased.

[NOTE.—In answer to a formal notification by the Secretary of his election, Mr. Walcott did not accept membership.]

Professors Hitchcock, Stevenson, Williams and Frazer, Reporters of Sub-Committees, having resigned these offices, the following members were elected to fill their places, viz.: Professors Hitchcock, Newberry and Scott, and Dr. Bell. The various sub-committees are at present composed as follows:

LETTER	SUBJECT.	REPORTER.	MEMBERS OF SUB-COMMITTEE.	ASSOCIATES.
A	ARCHEAN.	C. H. Hitchcock.	Dana, Hunt, Pumelly, Winchell, Bell, Frazer, Hitchcock.	
B	LOWER PALEOZOIC.	N. H. Winchell.	Dana, Hall, Lesley, Winchell.	Walcott, Hyatt.
C	(Devonic.) UPPER PALEOZOIC. (Carbonic.)	J. S. Newberry.	Hall, Lesley, Stevenson, Williams, Newberry.	
E	MESOZOIC.	W. B. Scott.	Cope, Newberry, Scott.	
F	(Marine.) CENOZOIC.	E. A. Smith.	Newberry, Scott, Smith.	
G	(Interior.)	E. D. Cope.	Newberry, Scott, Cope.	W. B. Clark.
H	QUATERNARY AND RECENT.	R. Bell.	Hitchcock, Winchell, Bell.	

The list of the officers and members of your committee as constituted at present is as follows:

- Prof. JAMES HALL (President), M.S., A.M., M.D., LL.D., N. Y. State Geologist, State Museum, Albany, N. Y.
- Prof. J. S. NEWBERRY, M.D., LL.D., Columbia College, School of Mines, N. Y.
- Dr. T. STERRY HUNT, LL.D. (Cantab.), F.R.S., New York City.
- Prof. C. H. HITCHCOCK (Treasurer), Ph.D., State Geologist, Dartmouth College, Hanover, N. H.
- RAPHAEL PUMPELLY, U. S. Geologist, Newport, R. I.
- Prof. H. S. WILLIAMS, Ph.D., Cornell University, Ithaca, N. Y.
- Prof. J. P. LESLEY, LL.D., State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia.
- Prof. J. J. STEVENSON, Ph.D., University of the City of New York.
- Prof. E. D. COPE, Ph.D., 2102 Pine St., Philadelphia.
- Prof. EUGENE A. SMITH, Ph.D., State Geologist of Alabama, University. Tuscaloosa Co., Ala.
- Prof. N. H. WINCHELL, State Geologist of Minnesota, University of Minnesota, Minneapolis, Minn.
- Prof. JAMES D. DANA, LL.D., etc., New Haven, Conn.
- Prof. WM. B. SCOTT, Princeton, New Jersey.
- Prof. ROBERT BELL, M.D., LL.D., Ottawa, Canada.
- Dr. PERSIFOR FRAZER, A.M., D.Sc. (Univ. de France), 1042 Drexel Building, Philadelphia.

JAMES HALL, *Chairman.*

PERSIFOR FRAZER, *Secretary.*

THIRD PRELIMINARY REPORT OF THE COMMITTEE ON ANATOMICAL
NOMENCLATURE WITH SPECIAL REFERENCE TO THE BRAIN.

REFERRING to the general suggestion embodied in their last report, the committee now offer the following specific recommendations and ask to be continued:

1. That the adjectives *dorsal* and *ventral* be employed in place of *posterior* and *anterior* as commonly used in human anatomy, and in place of *upper* and *lower* as sometimes used in comparative anatomy.
2. That the cornua of the spinal cord, and the spinal nerve-roots, be designated as *dorsal* and *ventral* rather than as *posterior* and *anterior*.
3. That the costiferous vertebræ be called *thoracic* rather than *dorsal*.
4. That the *hippocampus minor* be called *calcar*; the *hippocampus major*, *hippocampus*; the *pons Varolii*, *pons*; the *insula Reilli*, *insula*; *pia mater* and *dura mater*, respectively *pia* and *dura*."

BURT G. WILDER, *Chairman.*

HARRISON ALLEN.

FRANK BAKER.

HENRY D. OSBORN.

T. B. STOWELL.

**REPORT OF COMMITTEE TO APPLY TO CONGRESS FOR A REDUCTION OF
THE TARIFF ON SCIENTIFIC BOOKS AND APPARATUS.**

YOUR committee begs leave to report progress as follows:

The item providing for the free importation of scientific books by individuals, which was introduced into the tariff bill of the last Congress, which bill was not passed, has been incorporated into the McKinley bill which is now under consideration by the Senate of the United States. This item embraces only books printed in languages other than English.

Representations have been made by your committee to members of the Ways and Means committee of the Senate to induce the committee to include in the free list, scientific books printed in the English language, which have been published by the English government or by English scientific societies. It is not known as yet whether the Senate committee has accepted this item or not, but the members addressed on the subject appear to be favorably disposed towards it.

In conclusion the committee think that substantial progress has been made towards obtaining the desired reforms and asks to be continued.

E. D. COPE, Chairman.

J. R. EASTMAN.

[The third member of the committee, Prof. S. A. Forbes of Champaign, Ill., whom the Chairman expected to see at the Association, has not appeared, so that his signature could not be obtained.]

**REPORT OF A COMMITTEE OF THE COUNCIL UPON A MEMORIAL IN
RELATION TO STANDARD TIME, A UNIVERSAL DAY, ETC.**

To the Council of the A. A. A. S.:—

THE committee appointed by the Council of the Association at the Toronto meeting to consider the recommendations of a proposed memorial discussed in Section A at that meeting, respectfully submit the following report:

The recommendations which it is desired by the terms of this memorial to address to the governments of the United States and Canada and to their several state and provincial governments, set forth that it would be in the general public interest: first, to legalize the regulation of time by standard hour meridians; second, to sanction and permit by legislative enactment the use of the twenty-four hour notation for clock dials whenever and wherever it may be deemed expedient to introduce the reform; and third, to move the governments of all civilized nations to formally accept the resolutions of Washington Time Conference of 1884.

With respect to the first of these propositions, your committee deem action unnecessary, since standard time is now well nigh universally adopted in the United States and Canada and since no legalization seems essential to give permanence and effectiveness to a reform whose merits are so generally recognized.

As to the second proposition, while fully admitting the intrinsic superiority of the twenty-four hour notation for clock dials, we consider the obstacles in the way of its general adoption so great as to render fruitless any efforts which may at present be made in that direction. Though this notation is now in use by a few railways on this continent, the general sentiment of railway managers and of the public especially is decidedly against it. Your committee deem it unwise, therefore, to urge the attention of legislative bodies to this reform at present.

The last proposition refers to the important resolutions of the International Time Conference held at Washington in 1884. Without going into details, it may be stated that the recommendations of this conference have not been fully adopted by any one of the

twenty-seven countries sending delegates to the conference. Most significant of all to us are the facts that the United States have not formally sanctioned the resolutions, and that these resolutions have failed to go into effect in the astronomical bureaus of the United States Navy Department by reason of opposition to them on the part of astronomers in those bureaus and in the states at large. It is practically certain, we think, that any recommendation by this Association of the adoption of the proposed reform would be at present and in the near future ineffective. The changes involved by this reform, especially in the preparation of ephemerides, are so great and so important that astronomers will very generally protest against anything short of concerted international action. The time to secure such concerted action does not seem to have arrived, and apparently it will not arrive until the terms and conditions of the reform have been more fully agreed upon by additional international conferences.

Your committee, therefore, while recognizing the merits and desirability of the improvements which the proposed memorial seeks to secure, would recommend that no action be taken by the Association at present.

R. S. WOODWARD.

WILLIAM A. ROGERS.

REPORT OF COMMITTEE ON THE MAINTENANCE OF TIMBER-LANDS AND ON THE DEVELOPMENT OF THE NATURAL RESOURCES OF THE COUNTRY.

AT the Toronto meeting of this Association, the following resolution, reported from Section I, was passed :

Resolved, That the Association, through its Council, appoint a committee to memorialize Congress in behalf of the establishment of a proper administration of the remaining timberlands in the hands of the general government, for the purpose of insuring the perpetuity of the forest-cover on the western mountain ranges, preserving thereby the dependent favorable hydrologic conditions.

Resolved, That the several great economies of our country demand careful and just consideration and encouragement by legislative enactments which will aid the scientific development of the natural resources of our country proportionately to the rapidly advancing conditions of our people in industry and science.

Resolved, further, That a committee of five be and is hereby appointed to present these resolutions and to urge the importance thereof to the President and the Congress of the United States and to the Premier and Parliament of Canada, and that such committee be instructed to prepare in proper form any data necessary and to use every honorable and earnest means to accomplish the purpose herein set forth, and that the president of this Association be hereby appointed the chairman of such committee together with four others whom he shall appoint.

In response to this resolution the president appointed as members of the committee, Messrs. E. W. Hilgard of California, C. E. Bessey of Nebraska, Wm. Saunders of Canada and B. E. Fernow of New York. The last named two members met with the president Nov. 12, 1889, in the office of the director of the Coast Survey.

Upon the recommendation of Mr. Mendenhall the committee considering its power to act separately upon the two resolutions embodied in the work assigned to the committee and having decided that it could do so resolved, that the committee for the present refrain from considering the second resolution in reference to the general economies as not specific enough for its action, but to give their best energies to furthering the first and specific resolution with reference to government action in regard to timberlands.

At the suggestion of Mr. Saunders, upon his statement that the timberlands in Canada are mainly controlled by the provincial governments, the words "and to the Premier and Parliament of the Provincial Governments" were added, as clearly in the intention of the resolution.

It was resolved that the chairman send a copy of the resolutions so amended to the President of the United States, with a letter explanatory, in order to suggest an embodiment of the proposed policy in the President's message, and Mr. Saunders was instructed to present a copy of the resolutions to the various Canadian governmental authorities and also to transmit to them the memorial to be drawn later, expressing the necessary modifications for Canadian conditions.

An informal discussion then was had with reference to the contents and recommendations of the memorial to be drawn and the manner of transmitting the same to Congress.

In regard to the latter point it was deemed best to interest the President of the United States and to ask him to send such memorial as a special message to Congress.

The committee then met in joint session with a committee created for a similar purpose by the American Forestry Association, and the two committees had a hearing and agreement before the Secretary of the Interior, trying to enlist his interest in the proposed legislation.

The proposed memorial to Congress was drafted, sent to the President of the United States, and by him forwarded with a special recommendatory message to the two houses of Congress; letter of transmission, memorial and message becoming thus a public document, as follows:

MESSAGE FROM THE PRESIDENT OF THE UNITED STATES, TRANSMITTING REPORT RELATIVE TO THE PRESERVATION OF THE FORESTS ON THE PUBLIC DOMAIN.

[Jan. 20, 1890.—*Read, referred to the Committee on Agriculture and Forestry and ordered to be printed.*]

To the Senate and House of Representatives:

I transmit herewith a letter of Prof. T. C. Mendenhall, chairman of a committee of the American Association for the Advancement of Science and president of that Association, and also the memorial prepared by said committee relating to the preservation of the forests upon the public domain.

I very earnestly recommend that adequate legislation may be provided, to the end that the rapid and needless destruction of our great forest areas may be prevented.

BENJ. HARRISON.

EXECUTIVE MANSION,

Jan. 20, 1890.

OFFICE OF THE COAST SURVEY,
Washington, D. C., Jan. 11, 1890.

SIR:—In accordance with a resolution passed by the American Association for the Advancement of Science at its last annual meeting, calling for the appointment of a committee to urge the importance of immediate action looking to the establishment of a proper administration of the timber lands remaining in the hands of the government, a copy of which resolution has been sent to you previously, we now beg to submit in duplicate brief arguments in favor of a change in our present forest policy, and respectfully request that you will transmit this statement to the Senate and House of Representatives of the United States, with such recommendations as you may see proper.

Very respectfully,

T. C. MENDENHALL,

Chairman of Committee,

President of the American Association for the Advancement of Science.

THE PRESIDENT OF THE UNITED STATES.

**MEMORIAL OF THE AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE IN BEHALF OF
A PROPER FOREST POLICY.**

To the President of the United States:

The first national legislation which recognized the necessity of looking after the forestry interests of the country in general grew out of the representations made before Congress fifteen years ago by a committee of the American Association for the Advancement of Science.

These representations led to the appointment, in the year 1887, of an agent and later the establishment of a forestry division in the Department of Agriculture, for the purpose of gathering and making accessible such information as would lead our people to a proper conception of the value and significance of a forest cover in the economic life of our nation.

Twelve years have passed, during which sufficient knowledge of our forest conditions and of the general relations of these to cultural, climatic and economic conditions has been gathered, to show that further action on the part of the general government is necessary if we wish to preserve this relation favorable to the future development of the country.

The American Association for the Advancement of Science, actuated alone by a desire to promote a rational development of the country's re-

sources has, therefore, appointed the undersigned committee to memorialize the President and Congress of the United States under the following resolution:

Resolved, That it is the sense of the American Association for the Advancement of Science that immediate action should be taken looking to the establishment of a proper administration of the remaining timberlands in the hands of the governments of the United States and Canada, for the purpose of insuring the perpetuity of the forest cover on the western mountain ranges, preserving thereby the dependent favorable hydrologic conditions.

Resolved further, That a committee of five be and is hereby appointed to present this resolution and to urge the importance thereof to the President and the Congress of the United States and to the Premier and Parliament of Canada and of the provincial governments, and that such committee be instructed to prepare in proper form any data necessary, and to use every honorable means to accomplish the purpose herein set forth, and that the president of this Association be hereby appointed chairman of such committee, together with four others whom he shall appoint.

The committee in presenting this memorial desire not to argue at length any theory as to forest influences or to discuss the present unsatisfactory condition of our forest areas and national timberlands — which has been amply done in the reports of the Secretaries of Agriculture and of the Interior — but they respectfully submit in support of the request of the Association such points as will explain and justify the presentation of this memorial.

(1) The action which is asked of Congress concerns only a particular part of our forest area, that part which is in possession of the general government, the property of the nation.

(2) It is asked upon the presumption that the present administration of this property, probably from ignorance of its proper value and its real significance, is unsatisfactory, and that a change of policy is immediately urgent if this value is to be retained and the far-reaching injury, which from its present rapid deterioration may be anticipated, is to be avoided.

(3) It is asked upon the presumption that the value of this property, situated mainly upon the watersheds of our western river systems, lies much more in its significance for the future cultural development of a vast adjoining country than in the material which it now furnishes to the pioneer settler and miner.

(4) It is also assumed that the only proper person to administer this property for the benefit of the country at large and the preservation of the dependent cultural conditions is the government itself, which alone can have an interest in the future of society beyond present and personal gain.

As the reports cited have shown, the administration of the timberlands has been unsatisfactory for lack of proper legislation and of provisions sufficient to protect this property against material loss and deterioration. Timber thieving and destruction by fire have been allowed to unnecessary-

rily waste this national property, while the officers in charge were powerless to protect it. The pioneer legislation, which may have been sufficient twenty-five years ago, has long outlived its usefulness and should make way for such administration as will meet the demands of civilized existence in settled communities.

A vast empire, considered useless not long ago, has been found capable of human occupancy and agricultural production if the means for its development, water, can be brought upon it, and the extent to which this land may be utilized depends upon the amounts of water available.

The opinions of our greatest climatologists have been divided as to the influence of forests on precipitation. But evidence, carefully and scientifically scrutinized, is accumulating which tends to show that, under certain conditions at least, such influence may not be improbable. However this may be, overwhelming evidence can be brought to show that a potent influence upon the distribution of available water supplies from rain and snow is exerted by a forest cover, so that a government having to deal with the problem of cultural development of a part of its domain by irrigation cannot compass the water question without at the same time giving attention and proper regard to the forestry question.

Removal of the mountain forest means invariably disturbance of the natural "run-off," favorable sometimes, unfavorable mostly.

It may be difficult to devise at once such a plan for the administration of these forests, with a view to their continuity, as can be put in practice under the present social and political conditions of that part of our country in which this timbered area is situated; and a special investigation of these conditions and careful adjustment between the present needs of the population for wood material and the future needs of a forest cover for hydrologic purposes appears desirable, although various measures for a forest administration which seem capable of practical application have been proposed.

We, therefore, the undersigned committee, in the conservative and scrutinizing spirit that should characterize the proposition of the scientific body which we represent respectfully recommend:

That a joint committee of the Senate and House of Representatives of the United States be appointed to consider the needs of legislation in behalf of the public timber domain with a view of providing for the appointment of a commission of competent men, salaried and employed for this service alone, for the purpose of investigating the necessity of preserving certain parts of the present public forest area as requisite for the maintenance of favorable water conditions and to devise a practical plan for the permanent administration of such parts of it as shall appear desirable to be retained under government control.

The committee further recommends that, pending such investigation, all timberlands in the hands of the United States be withdrawn from sale and provision be made to protect the said lands from theft and ravages by fire and to supply in a rational manner the local needs for wood and lumber until a permanent system of forest administration be had.

It is also suggested that inasmuch as the various departments and government bureaus, namely, the Department of Agriculture in its Forestry Division, the Department of the Interior in its Land Office and Geological Survey, the Department of War in its Signal Office, the Treasury Department in its Coast and Geodetic Survey, are more or less closely interested in this matter and have collected data useful in the work of such a commission, these departments should coöperate and act as advisers of said commission.

All of which is respectfully submitted.

T. C. MENDENHALL,
President of the Association and Chairman.

B. E. FERNOW, of New York,
Secretary.

E. W. HILGARD, of California,
C. E. BESSEY, of Nebraska,
WM. SAUNDERS, of Canada,

Committee.

After this the individual members of the committee addressed letters to representatives and senators, urging action and, for the rest, acted in conjunction with the American Forestry Association in furthering the passage of a bill looking to the accomplishment of the object in view.

Such a bill was introduced by Representative Mark H. Dunnell and through him was obtained the appointment of a sub-committee in the committee on public lands, charged with the special duty of considering and devising proper forest legislation. The secretary of your committee has been repeatedly before this sub-committee and is assured of their interest and full appreciation of the importance of this legislation.

Since, however, the public lands committee has had much important work before it and since a thorough revision of the land laws in all its parts is contemplated, including the present method of disposing of timberlands, action upon this particular legislation has been deferred until the more comprehensive plans of land legislation could be digested. But the assurance is given that early in the next session such bill for a forest administration as will meet the views of the committee on public lands will be prepared and laid before the House.

In the Senate the memorial was referred to the committee on agriculture and forestry. A number of senators being heartily in

sympathy with the aims of the movement and ready to support it when coming from the House, no efforts were made to further interest them in the subject.

A continuation of the committee until the sought-for legislation may be obtained, is herewith recommended.

T. C. MENDENHALL.

WM. SAUNDERS.

CHARLES E. BESSEY.

B. E. FERNOW, *Secretary.*

FOR REPORTS OF SEVERAL OTHER COMMITTEES MADE THROUGH THE
SECTION OF CHEMISTRY, SEE SECTION C.

SECTION A.

MATHEMATICS AND ASTRONOMY.

OFFICERS OF SECTION A.

Vice President.

S. C. CHANDLER of Cambridge, Mass.

Secretary.

WOOSTER W. BEMAN of Ann Arbor, Mich.

Member of Council.

CHARLES H. ROCKWELL of Tarrytown, N. Y.

Members of Sectional Committee.

H. S. PRITCHETT of St. Louis, Mo., **J. E. KERSHNER** of Lancaster, Pa.,
J. A. BRASHEAR of Allegheny, Pa.

Member of Nominating Committee.

W. A. ROGERS of Waterville, Me.

Members of Sub-Committee on Nominations.

ORMOND STONE of Univ. of Virginia, **H. T. EDDY** of Cincinnati, O.,
R. S. WOODWARD of Washington, D. C.

ADDRESS
BY
SETH CARLO CHANDLER.

VICE-PRESIDENT, SECTION A.

THE VARIABLE STARS.

It is proposed to spend the short time which it is my privilege to occupy, in opening the proceedings of this section, in an account of the progress and present condition of knowledge with reference to the variable stars. Notwithstanding the industry in observation and research, and the ingenuity in speculation, which have been lavished upon these wonderful objects during the last hundred years, they remain, nearly to the same degree as in the beginning, enwrapped in mystery, and we seem to be as far as ever from a rational basis for the classification and interpretation of their perplexing phenomena; so that our ideas as to the nature and operation of the underlying causes are still vaguely speculative. The construction of a correct theory of the subject must await a larger conquest of the domain of fact; and to the patient accumulation of the material of observation, therefore, we must hopefully look for the solution of this most interesting cosmological enigma.

In attempting here a brief historical outline of our subject, it would ill suit the occasion, in this midsummer hour, to weary you by ransacking the historical lumber room for references to the Chinese annals, the Greek and Roman historians, and the chronicles of the middle ages. The vague fables and traditions which we there find, while they would perhaps be suitable in a monograph, are of no scientific importance, and constitute in no real sense the beginning of knowledge of the subject. Even the advent of the well authenticated new stars, so-called, of Tycho, Kepler and Jan-

sen, near the opening of the seventeenth century, can be considered as the beginning only in a very partial sense. These phenomena, while they impressed for the first time upon astronomers the certain conviction that the stellar universe is not entirely dead, conveyed rather the idea of catastrophe than of the orderly succession of phases of a systematic life, such as the variable stars, properly so termed, exhibit. Thus it happened that when, toward the middle of that century, stars were found which disappeared and again reappeared, the progress was so slow in the perception of the fact of the recurrence of these apparitions at uniform intervals of time. The discovery of this highly characteristic phenomenon of periodicity marks, it seems to me, the true initial epoch in the history of this branch of astronomy. To Bouillaud is due the credit of having first distinctly recognized, in the case of *Mira Ceti*, that the light-variations follow a moderately regular course, that the star gradually declines from its greatest brilliancy, remains invisible to the eye for several months, then reappears and gradually recovers its original brightness. He detected also two other facts which we now know to be generally characteristic of this class of variables; namely, that the period is not exactly uniform, and that the maximum brightness is not always the same.

Notwithstanding the interesting nature of this capital discovery of a class of objects revealing in operation an unknown law of physical change, and endowing with life a portion of the visible universe hitherto dead, according to all appearance,—a discovery equal in importance to that of the motions in the binary systems, which so stimulated inquiry a century later in another department of sidereal astronomy,—the spirit of observation does not seem to have been aroused to the desirability of orderly and continuous records of the new class of phenomena. To Kirch and Hevelius we owe almost all the information of their time that we now possess. Nor were any new variables detected, after those in *Cetus*, *Hydra* and *Cygnus*, for about one hundred years. We find abundant evidence, indeed, that the subject of stellar variability excited lively interest, and the records of the time abound with alleged cases of the sort,—Montanari himself alone took credit for more than a hundred such, and other enthusiasts contributed their share to the mass of unverified suggestion. But the uncritical spirit of the age in matters of observation of this kind was fatal to progress. A most brilliant discovery of a new and remarkable kind of light-fluctuation—

namely, that of *Algol*—came within reach, indeed, of both Montanari and Maraldi, but slipped from their grasp on account of lack of persistence in following the clew given by their observations. But the prize lost by this inattention fell, nearly a century later, into the meritorious hands of an English amateur of astronomy, John Goodricke, who, with his friend Edward Pigott, by curious but well-deserved good fortune, established, by their subsequent detection of five other variables, the existence of what we now regard as three new types. It does not seem to me that the merit of these observers has been sufficiently appreciated. This merit lies not alone in the patient and sharp-eyed scrutiny by which they picked out these striking typical instances from the thousands of stars visible to the naked eye, at a time when no uranometry or other record of their brightness existed which could be of the slightest service in the work; but also in the fact that they were the first who conducted observations upon these objects with a painstaking care and orderly method, which imparts to them a value nearly or quite equal to that of modern observations.

The work of discovery now languished for nearly half a century, the record for which is comprised in the five new variables found by Harding, mainly in the construction of his celestial atlas, and about an equal number of sporadic stars by other observers. A little before the middle of the present century, however, numerous additions began to accrue incidentally from the search for the asteroids and the construction of the zodiacal charts to facilitate the same. Among the largest contributions from this source we have twenty-one from Hind, seventeen from Peters and fourteen from Pogson, together with a few each from Chacornac, Hencke, Palisa and others. In all, these indirect accretions through the asteroid search constitute more than one quarter of the whole number of known variables.

Meanwhile the labors at Bonn upon the *Durchmusterung* of the northern heavens gave a still greater impetus to the subject, either directly, by the numerous additions by Argelander and his co-workers in the construction of that monumental work, or collaterally by the assistance it has afforded other astronomers in recognizing fluctuation of light among the telescopic stars. Similar results have flowed from the continuation of the Bonn survey to the southern tropic, by Schönfeld, which will undoubtedly in the near future still more largely enrich our knowledge in this way,

for this portion of the sky. While it is not easy to distinguish and properly accredit the discoveries of Argelander and his coadjutors, we may perhaps approximately assign seventeen to him, nine to Schönfeld and three to Krueger. The fourteen variables of Baxendell were probably also very largely detected by the industrious use of the Bonn charts, and to the same helpful aid we may attribute many other subsequent discoveries.

Contemporaneously with the progress among the telescopic stars just recounted, the work so well begun by Pigott and Goodricke among the brighter ones was again taken up by Schmidt, stimulated by the advice and example of Argelander. During a long and most honorable career of forty years he perseveringly cultivated this field, adding more than a dozen new variables, mostly of short period, besides a few in or near nebulas, of the fainter class. The Grecian horizon permitted him to extend our knowledge to a somewhat more southerly limit than previous observers had covered, but the southern sky still remained almost an unknown region. Within the last twenty years, however, the labors of Gould have fortunately placed the other celestial hemisphere on an equality with ours as respects the brighter variables, and his name stands easily at the head of the list of contributors to this department of astronomy up to the present time. That portion of the region of Gould's uranometry accessible in this latitude has since been again faithfully gleaned by Sawyer, who has added seven variables to our list. Among other contributors at various times may be mentioned Auwers, Winnecke, Dunér, Espin and Gore; and many other observers have added three or less each. Thus the catalogue of stars whose variability is certainly ascertained has grown, until it now comprises two hundred and thirty-eight stars, to which five or six new ones, on the average, are annually added.

Let us now escape from the dry statistics of mere discovery, and pay our tribute to the conscientious and patient industry of those who, by unremitting labor in observation of the phenomena presented by the objects so revealed to us, have laid the foundation, and by their investigation of results have raised the superstructure of our present knowledge, which it will be our privilege, in a moment, to examine. Among the earlier partakers in this task, the names of Olbers, Herschel, Wurm and Westphal should be added to those already recorded. After them the subject fell into almost entire neglect for a score of years, until the dawning of the new

era inaugurated by Argelander, who, by collecting, sifting and discussing all previous data, by the contrivance of new and effective methods of observation and reduction, and energetic employment of them, created anew this branch of the science, while, by his writings, now become classics, and his incitement to engage in the work of the younger generation of astronomers who looked to him for leadership, and whose names have since lent such lustre to astronomy, he kindled a fire of influence which yet burns with undimmed vitality. The mantle let fall by him has since been worthily worn by Schönfeld, whose investigations will never lose their place as models in this department. Inspired from the same source and bearing the same impress is the work upon variable stars of Auwers, of Gould, of Winnecke and of Oudemans. Schmidt, too, took encouragement from the same fountain-head, and left a legacy to astronomy of a storehouse of observations which is almost overwhelming to contemplate as the accumulated labor of one man with but limited instrumental means. Nor can we forbear, even if but a single word can be spared, to accord the praise due to the collaboration of Hartwig, Safarik and Wilsing in Germany, of the Baxendells and Knott in England, and of Sawyer, Yendell and Parkhurst in our own country, in addition to others, not less deserving, for their part in the service of observation.

From the large body of observational material thus amassed have emerged, by gradual approximation and repeated discussion, the salient facts by which the character of each star is determined from its light-fluctuations. This work has been attended with peculiar difficulty. In other sorts of astronomical measurement, the methods of reduction are capable of being defined with sharpness by mathematical processes, based upon accurate reduction-elements. With variable star observations, on the contrary, the standpoint of our knowledge is so low that their definitive reduction cannot be conducted upon settled principles, as in micrometrical or meridional work, but is to a considerable extent arbitrary even in the most refined and sagacious treatment at present possible, and the results will vary with the judgment of the computer. As a consequence, each new investigator of a given star, in incorporating new material in his discussion, can secure homogeneity only by going over the whole ground afresh, starting from the raw facts of the original records. The progress of development has, therefore, from its nature, been slow and laborious, and has correspondingly

delayed the subsequent process of comparison and coördination of these isolated facts, which is the next step toward the recognition of the general laws governing the phenomena, a knowledge of which is indispensably preliminary to the laying of the foundation of a true science of the variable stars.

When all the facts thus laboriously acquired are broadly surveyed and brought to focus, we are enabled to distinguish with more or less certainty various general characteristics pertaining to the phenomena of these wonderful objects. Let us take these up one by one, in a natural rather than an historical order. After this we may be in a position to judge whether it is possible to draw any conclusions as to the real nature of these changes of brightness and the physical condition of the bodies exhibiting them, and what tangible basis exists for the numerous speculations which have been indulged in with regard thereto.

In the first place there arises a question of high importance in its bearing on the community of nature between the variable stars and the other stars of our sidereal system : namely, what proportion of the stars are variable? On this it is to be remarked that, although in the construction of variable star catalogues it is an essential precaution against confusion that they shall include only those whose fluctuations, of whatever kind or amount, have been ascertained beyond peradventure, it is certain that besides these there is a very large number in which changes of brightness do actually occur, but of so furtive a kind as to be complicated with the unavoidable errors of observation, and which, in default of concurrent and undoubted testimony, must for the present be excluded from the catalogues. The evidence in these cases is too defective for us to hazard a guess as to the ratio which they bear to the whole number of visible stars. An authority of the very highest rank, Dr. Gould, has recorded his deliberate conviction that a very large proportion of the brighter stars, at least, are actually variable in a slight degree. Such a judgment on so wide an experience, whose results he is unable to interpret in any other way, is not to be lightly weighed. Unfortunately, the position is one which is susceptible neither of proof nor disproof. It can be asserted with confidence, however, that such a proposition cannot be true if the limit of its terms be slightly extended to fluctuations of small but easily recognizable amounts ; for in regard to such we have a certain basis for inference — from the large number of stars, thousands in the ag-

gregate, which have been carefully and concurrently observed as comparison-stars for the known variables,—that variability to the amount of, say one-fifth part of the mean or normal light, can be present in but an exceedingly small proportion of the stars in general. But whatever opinion may be held on this question, it is sure that we are yet acquainted with but an insignificant portion of the whole number; and that, when our knowledge of the fainter stars becomes as intimate as for the brighter ones, our catalogues of the variables will grow in manifold proportion. As to the absolute number there can be nothing but the rudest kind of guesswork, and that only as to the inferior limit. But, without fear of overestimate, there are probably two or three thousand at least which at maximum brightness could be seen in an ordinary field-glass; while the number visible in our largest telescopes would probably run into the hundreds of thousands. In this connection it may be stated that Schönsfeld is inclined to accord with the impression of Peters, who had especial experience with the fainter class of variables in the construction of his series of charts, that the proportional number decreases as we descend in the scale of brightness. This opinion is merely a surmise, and for the present incapable of proof.

The next topic to be disposed of relates to the numerical distribution of the variables with reference to the times occupied in completing a single cycle of their changes, commonly called the period. These range from the wonderfully short period of less than eight hours in the case of the remarkable variable recently found by Paul, to about two years at the other extreme, the longest for any of the certainly determined periodical stars. Between these limits there is a highly significant deviation from uniformity of distribution which was first pointed out by Schönsfeld. From the seventy-one stars then at his command this systematic relation appeared rather obscurely, but afterwards with increasing emphasis as the data waxed in volume, until it can no longer be deemed fortuitous, or due to any circumstance of the method of discovery of the variables, but as having a real connection in the nature of things. This peculiarity of allotment is shown by the following tabulation of the one hundred and seventy periodical variables now known. The preponderance of the numbers for periods of the shortest class, under twenty days, and also for those of nearly a year, as well as the striking paucity at about three or four months, are visible at a glance. It may be added that, for reasons which I have else-

where given, we may infer that the tendency to excess near the annual period is actually greater than here appears.

LIMITS OF PERIOD.	NUMBER.
Under 20 days	28
Between 20 and 50 days	5
" 50 " 80 "	8
" 80 " 110 "	1
" 110 " 140 "	4
" 140 " 170 "	5
" 170 " 200 "	6
" 200 " 230 "	13
" 230 " 260 "	7
" 260 " 290 "	17
" 290 " 320 "	17
" 320 " 350 "	17
" 350 " 380 "	20
" 380 " 410 "	9
" 410 " 440 "	8
" 440 " 470 "	4
" 470 " 500 "	3
Over 500 "	4

The prevailing tendency to a red or orange color among the variable stars, first noted, I believe, by Lalande, became more pronounced as the list grew, until it was commonly recognized that a connection of some sort exists between color and variability. Schönsfeld, who first critically examined this point, found that at least five-sixths of the variable stars are decidedly reddish, and formulated the proposition that "a stellar photosphere whose special chemical condition manifests itself to us by the redness of its light, is also particularly inclined to oscillations in brightness." Much fuller and more exact data at the present time confirm this proposition beyond doubt. The more intimate connection of simultaneous alteration in color and brightness, for particular stars, which Hind and Pogson ascribed, does not appear to be borne out. Neither the observations of Argelander, Schönsfeld, Winnecke, or the writer, reveal any such interdependence. The position is indeed

one which it would be unsafe to accept without irrefragable proof, as there is abundant room on physiological grounds for referring any such apparent effects to subjective causes.

There is, however, another sort of color relation which is susceptible of pretty satisfactory demonstration. This is expressed in the following proposition, which I have elsewhere given : "The redness of the variable stars is, in general, a function of the length of their periods of light-variation. The redder the tint, the longer the period." It is not out of place to repeat here the final table of results on which the proof of this depends, containing the average periods and average redness on a suitable arbitrary scale, of the variables in groups.

AVERAGE.		AVERAGE.	
PERIOD.	REDNESS.	PERIOD.	REDNESS.
517.6	7.3	307.9	4.2
449.8	8.1	299.0	2.9
423.4	6.8	285.2	3.0
408.4	4.7	276.1	8.9
383.6	5.5	269.4	8.4
376.1	8.9	252.7	2.2
364.8	4.7	220.7	2.3
355.6	5.1	203.2	2.3
342.5	2.6	178.7	2.0
333.5	3.8	153.0	1.8
325.3	8.1	49.7	1.8
322.0	8.1	11.8	1.8
315.6	3.5	4.8	1.4

It is needless to point out the significance of this association of two sets of phenomena, relating in all probability, one to the dynamics of the star, the other to the chemical condition of its photosphere. Its importance as a touchstone for hypotheses in regard to the causes of stellar variability is evident.

To complete this part of the subject it may be added that all ten of the stars of the *Algol*-type are strikingly white, without exception, to my eye, at least; and also that all of the short-period variables of the type of η *Aquilæ*, are either white or have but a moderately

yellowish tinge, excepting *U Sagittarii*, which is of a decided orange.

An instructive comparison may also be made of the average range of the variations of light with the periods. Here again the results will be quoted from a previous paper, somewhat rearranged and condensed for the sake of perspicuity, in a table containing groups following the order of the average period in the first column, with the averages of range of variation in stellar magnitude in the second column, and in the third the corresponding ratio of the brightness at maximum to that at minimum, computed with the light-ratio unit 0.375, which is approximately its true mean value in the scale ordinarily used, generally known as Argelander's.

A most distinct relation is here shown, which, whatever its true law, is manifestly not one of proportionality of range to period. For periods under two months the maximum brightness is pretty uniformly about three times that at minimum; from four up to seven or eight months it is thirty times; while for longer periods it is about sixty times.

PERIOD.	RANGE IN MAGNITUDE.	RATIO OF MAX. TO MIN.	PERIOD.	RANGE IN MAGNITUDE.	RATIO OF MAX. TO MIN.
602	4.5	49	281	5.0	75
429	4.5	49	270	4.8	68
385	5.4	106	247	5.0	75
375	5.2	89	229	8.0	13
361	5.0	75	214	4.1	34
348	4.6	53	184	4.1	34
339	4.2	38	139	8.5	30
326	4.8	41	50	1.1	8
323	4.6	53	23	1.8	8
314	4.6	53	9	1.2	8
306	4.5	49	7	1.4	8
291	5.1	82	5	1.0	8

Let us now see what observation has taught with reference to the character of the fluctuations of brightness within the period, in other words, the nature of what are termed the light-curves. The study of these was entirely ignored until Argelander undertook the critical discussion of them for several variables. Subsequent in-

vestigators, notably Schönfeld, have done the same for many others; nevertheless our information on this point is much in arrears, as we have not even tolerably accurate light-curves for more than a quarter of the periodical stars, and only the most general information thereupon for but a part of the remainder.

A comparative examination of these light-curves reveals certain family resemblances, and enables us to distinguish a number of types. First and most remarkable is the peculiar form for which *Algol* serves as the type-star. In this the light remains constant during the greater part, on the average four-fifths, of the period, then rapidly diminishes, and after passing minimum increases at a nearly equal rate in some cases, somewhat more slowly in others, until maximum is again reached: the obscuration of light amounting in general to half or three-quarters of the whole. Another singular type is in some respects the reverse of this, the star remaining at minimum during nearly the whole of its period, then increasing twenty or thirty fold with extraordinary suddenness, then somewhat more slowly fading away to its normal faintness. For the rest of the periodical stars the fluctuations are not thus confined to a particular portion of their periods, but are in general continuous, with more or less gradual rise and descent, at varying rates. In some stars, generally with the shorter periods, the phases recur with great constancy in different periods; in a much larger number there are marked irregularities, which are apt to be greater in stars with the longest periods. In two or three instances the light curve is double, there being a well-defined secondary minimum about midway between principal minima. It is a rather common characteristic, particularly of the more regular stars, that the increase is more regular than the decrease, the latter being interrupted part way in its course by a period of nearly stationary brightness, this feature sometimes amounting almost to a secondary maximum and minimum. The increase is generally more rapid than the decrease, a circumstance which we shall presently inquire into more narrowly.

Then, besides the distinctly periodical stars, we have a considerable number in which there is absent any discernible law or regularity, and an intermediate group in which it appears in a very weak degree. One or two there are which remain steady during long intervals of time, then begin without warning a series of astonishing and apparently lawless changes, and again become quiescent. Finally there are the new stars, commonly so called.

Such, succinctly described, are the principal typical forms which these light-variations assume, of which there are many minor modifications in particular cases. The successful comparative study of phenomena so complex must await a larger and more precise knowledge than is now at hand. Still, notwithstanding the deplorable poverty of our information, we can extract some hints of the existence of certain general relations in the light-curves. The analogy was long ago noticed by Argelander that by far the larger proportion of the periodical stars increase in brightness more rapidly than they diminish, the only exceptional class being the *Algol*-type stars. A more intimate examination yields results of great interest. There is evidence of a curious relation between the length of the period and the ratio of the time of increase to that of decrease. Thus we have the following numbers, each the average of a group of four or five stars. Unity, of course, corresponds to equal times of increase and decrease, values less than unity to greater rapidity of increase, and *vice versa*.

LONG PERIOD VARIABLES.		SHORT-PERIOD VARIABLES.	
PERIOD.	RATIO OF INCREASE TO DECREASE.	PERIOD.	RATIO OF INCREASE TO DECREASE.
461.7	1.055	57.5	0.639
422.9	0.835	22.7	0.609
383.1	0.804	8.8	0.758
345.4	0.536	7.0	0.633
312.8	0.852	5.0	0.656
269.8	0.866		
215.5	0.897		
186.7	0.980		
136.1	1.020		

We cannot fail to mark the discontinuity in the relation here shown, as between the variables of long and short period. The average ratio for the latter is about 0.65, and the value is sensibly the same for all five groups of that series. The average ratio for the former is about 0.87; but a curious law here prevails. In the extreme groups of the series the ratio is in excess of unity, but it decreases in both directions towards the middle, corresponding to

periods of a little less than a year. That the exceptionally small value for this group is not accidental, is shown by the accordance of all the individual stars contained in it, namely :

<i>o</i> Ceti	0 49	R Canis minoris	0 51
T Arietis	0.61	S Coronæ	0.50
R Geminorum	0.41	R Aquilæ	0.64

Should the relation in question be borne out by future investigation, we may find a plausible explanation by considering it in connection with the preponderance in the number of variables with periods of nearly a year, already treated of in an earlier part of this paper. Thus it may be that what we ordinarily term the long period variables really comprise two distinct classes, in one of which the times of increase and decrease are approximately equal, and the individuals are indiscriminately of all periods, while in the other the increase is very rapid and the decrease very slow, and the periods are all about a year long.

We must now pass in review a most perplexing class of phenomena, which will ultimately be of the highest import in the theory of the variables, namely, the irregularities with which the various elements of their light-variation are affected. It has already been mentioned that the first perception of such inequalities, in the case of *o* Ceti, is due to Bouillaud in the seventeenth century. Afterwards they were noted in other stars, but the successful attempt to reduce them to numerical laws was a great stride forward, for which, again, we must thank Argelander. He detected the existence of such inequalities, and determined the equations for their expression, in a few conspicuous instances; Schönfeld added as many more; and, aided by the much larger body of data since collected, the writer has fortunately been able to investigate similarly a score of other cases, besides demonstrating the presence, without formulating them, of like irregularities in a very large number of stars. For the most part these deviations from a uniform period are manifestly periodic, the same values recurring after a given number of single periods of the star, and can be expressed by formulas of sines. In some of them the interval during which the star has been under observation covers so small a portion of the cycle, that the deviations can be more conveniently treated as secular, so that the alterations in the period appear to increase with the time either in direct proportion, or in a higher ratio.

Anything like a full or technical statement with regard to these numerical equations would be here entirely out of place; but it is

desirable to give a few particulars, to illustrate their general amount and nature, and to enforce some significant differences pertaining to the various classes of stars.

Among the stars of the *Algol*-type we have established beyond doubt a decrease of period between the successive minima, of four ten-thousandths of a second of time in *U Ophiuchi*; a decrease of nearly four-thousandths of a second in *U Coronæ*; an increase of about six-thousandths of a second, which is slowly diminishing with the time, in *U Cephei*; of a variable change, whose maximum value amounts to five-thousandths of a second, in *Algol*; and, in an investigation yet unpublished, of an absolute constancy, so far as secular change is concerned at least, in δ *Libræ*. In *Y Cygni* there appear to be anomalously large periodical inequalities, as yet obscurely understood, amounting to perhaps nearly a second of time at the maximum value, in a cycle of perhaps one or two hundred periods; and λ *Tauri* exhibits a similar phenomenon, very much smaller, and equally obscure in its nature. In the three other stars of this class no variation of period has yet developed, except, perhaps, uncertainly in *S Canceris*.

In the other class of short-period variables the period of β *Lyræ* was long ago shown by Argelander to be increasing by five-sixths of a second, the rate slightly diminishing with the time. With this exception there has yet appeared no sign of secular variation, although several of them have been under observation long enough to have developed any sensible terms. The slight want of uniformity in η *Aquilæ*, which Argelander supposed to exist is, I think, referable to personal differences in the observers. Nor have any but the most evanescent symptoms of periodical terms manifested themselves.

Among the long-period variables, on the contrary, systematic inequalities are prevalent to such an extent as to make it extremely likely that they are universal, and inseparably associated with the type. I have found them in at least forty stars; and, indeed, cannot call to mind a single instance where the observations are sufficiently continuous to permit them to develop at least partially, in which they are not manifest in some degree. They are in general periodic, running through cycles of fifty or sixty periods on the average, sometimes of only twenty-five or thirty periods. The amplitude of these inequalities is very considerable, the accumulated effect, as expressed in the extreme deviations from a uniform period, often amounting to nearly one-fifth part of the star's period.

Many of them are closely amenable to quite simple laws, but some, as *o Ceti*, *R Hydræ*, *χ Cygni* and *R Virginis*, involve complex expressions.

The facts here given raise a strong presumption of a generic difference in the types of irregularities by which the various classes are affected. In the stars of the *Algol*-type they are small and secular, or at least operate in comparatively long cycles. In the ordinary short-period type they are apparently almost entirely absent. In the long-period type they are large, periodic, and generally prevalent.

There is another sort of inequality to which the variables are subject, namely, those which appear in the light-curves and in the brightness which they attain in their principal phases. The investigation of these has proved fruitless, so far as the discovery of any laws is concerned. In no case does there seem to be any connection between the deviations of the times of maxima or minima from a uniform period, and the simultaneous deviations from the mean brightness at those epochs. While there are stars, like *U Monocerotis*, *X Cygni* and *R Scuti*, which display curious alternations, either singly or in series, of bright and faint phases, the rules governing them elude us. The only general proposition which can be enunciated about them is, perhaps, that of Schönfeld, that "those stars which are subject to the greatest oscillations of period also show the greatest oscillations of brightness in identical parts of the period."

The laws of aggregation among the variables form an interesting problem, but its satisfactory solution must be postponed to a future epoch, when the number of known stars shall have very greatly increased, as a result of systematic search for them embracing the whole sky. The small number now known are too likely to mislead us by fortuitous features in their distribution, which is also influenced by factitious elements such as the unequal gleaning of the two hemispheres, and the excess of variables in the zodiacal region due to the asteroid search. Nevertheless, eliminating as far as possible these sorts of error, we can get some instructive results. It has long been a familiar surmise that an abnormal proportion of the brighter variables lie near the Milky Way. Stricter investigation appears to confirm this idea, and further shows that there is no such tendency among the other classes of variables, thus emphasizing still more the fact of a difference of nature and origin, which already abundantly appears in the other characteristics outlined in this paper.

- If we take pains to exclude the regions which would improperly affect our results, we have the following relative densities of the variables and the other stars, for belts 20° wide taken parallel to the Galactic circle, the densities in each column being expressed in terms of that of the central belt.

GALACTIC N. P. D.	RELATIVE DENSITY OF VARIABLES.		RELATIVE DENSITY OF STARS IN GENERAL.	
	TELESCOPIC.	BRIGHT.	TELESCOPIC.	BRIGHT.
0-20	0.17	0.00	0.35	0.55
20-40	0.87	0.18	0.86	0.57
40-60	0.65	0.08	0.45	0.64
60-80	0.68	0.20	0.88	0.79
80-100	1.00	1.00	1.00	1.00
100-120	0.66	0.40	0.77	0.91
120-140	0.28	0.00	0.47	0.57
140-160	0.31	0.00	0.41	0.48
160-180	0.96	0.00	—	—

Comparing the second and fourth columns, there appears to be no general difference in the character of the two series, from which we infer that there is no manifest tendency to a different law of distribution among the telescopic long-period variables from that which prevails for the stars of our system in general, in respect of their relation to the Milky Way. The third and fifth columns are of a strikingly diverse character, showing that the tendency of the short-period variables (other than those of the *Algol*-type) to aggregate near the plane of the Galaxy in excessive proportion, is very pronounced. Notwithstanding the small number of variables involved, it will be singular indeed if this should prove to be merely accidental. On the celestial charts this phenomenon exhibits itself in a stream of bright variables, not in the course of Dr. Gould's belt of bright stars, which we might expect it would approximately follow, but more nearly in that of the Milky Way itself, adhering closely to the southern branch of the latter in its bifurcation near *Cygnus*.

A classification of the variables in Galactic longitude, separately made for both hemispheres, shows, in both, maxima at 30° and 165° longitude (reckoned from the ascending node of the Galaxy

upon the terrestrial equator), corresponding, respectively, to points in the sky near β *Cygni* and α *Orionis*. Whether this has any real meaning must be left for the future to show. In the meantime we cannot be too cautious in accepting conclusions of this kind drawn from our present fragmentary information.

Finally, the spectroscopic method of observation has, in the variable stars, an exceedingly rich field for its application, and from its peculiar capabilities we are justified in high anticipations of future conquests in this direction to supplement the knowledge obtained by other means. We have an earnest of this in the recent admirable discovery of Vogel with reference to *Algol*, of which a word later. Otherwise the observations of variable-star spectra are not yet sufficiently comprehensive to permit the deduction of any general truth. So far, the indication is that the variables will not crystallize harmoniously, by the recognized spectroscopic stellar types, according to the classes suggested by their other peculiarities; a result which perhaps ought not to surprise us, as it is a natural one if, as may be, mechanical rather than chemical causes largely control the phenomena.

Having thus endeavored to delineate, at what may seem tiresome length, a picture of our present knowledge in all its general aspects, the task which was set us is done. It would be a cruel tax upon your patience, and outside the original intention of this address, to enter upon the question of the causes of the variations of stellar light, whose highly involved features it has here been attempted to reduce to some sort of order. An exposition of the various hypotheses which can be framed, and the confrontation of them with the facts of observation, need more ample opportunity than is afforded in the few minutes remaining, and would be a trespass upon the kind toleration with which you have so far listened. I may take occasion to do this at a subsequent meeting of the Association. The subject is hardly ripe for mature discussion. Natural and obvious analogies of course suggest, as indeed they did in the very infancy of this branch of astronomy, that the explanation of these periodical variations of brightness lies in certain consequences of rotation of the stars upon their axes, or in motions of revolution of one body about another; and by introducing modifying suppositions of unequally illuminated surfaces, irregular forms, tidal action upon light-absorbing atmospheres, spontaneous and intermittent explosions, meteor swarms, and the like, much may be

plausibly accounted for if we give free rein to the fancy, and do not shrink from piling one supposition upon another in inverted pyramids, merely to see them topple over. For but one order of variables, only ten in number, have we an hypothesis in which we can feel a slight confidence that it may be finally established, and even this is likely to be seriously modified. This is the theory of eclipse by an occulting satellite, propounded by Goodricke a hundred years ago, to which subsequent speculators have added no force whatever until Vogel's recent brilliant and apparently satisfactory demonstration, by his spectroscopic method, of an orbital motion in *Algol* synchronous with its period of light-variation. For this peculiar kind of variability Goodricke's theory may possibly hold its ground, although not in the form of an occulting satellite, in the ordinary meaning of that term, unless certain grave objections are first disposed of. As to the variables outside of this small class we are yet in the dark. Nature guards well the mystery, and from behind the veil smiles at the immature knowledge and cheap ingenuity of the shallow speculations in the scientific transactions, and elsewhere—and are we ourselves not sometimes tempted, let it be whispered, to share her mirth? Her temple is not to be entered by force, nor her secret stolen from the shrine by legerdemain; and while she seems to rejoice in holding her inquisitors for awhile at bay, she will finally yield the key into the hands of her earnest votaries, who patiently set themselves to read the riddle of the phenomena which hide the truth beyond. It is on the faithful effort to collect the data with regard to these phenomena that our hope of success depends. In what has been said it is not meant to hold speculative theorizing in undue disrepute, but only its abuse. The origin of phenomena is, of course, the noble and ultimate aim of all inquiry in the natural and physical sciences, and I envy no man whose mental vision, either by constitution or habit, is so limited by the horizon of mere facts, that he can despise the indulgence in speculation upon their outcome, and who plods along the high road of science with his eyes bent upon the search for the stones of fact in his path, without desire to raise them now and then to gaze upon the scene beyond. The mere observer of the isolated facts of nature, who feels no impulse to speculate upon their possible meaning, lacks one of the highest elements of the genius for the collection of facts, and loses one of the safeguards against misdirected inquiry.

PAPERS READ.

DOUBLE-STAR OBSERVATIONS. By Prof. G. W. HOUGH, Evanston, Ill.

[ABSTRACT.]

THE increased optical power secured during the past quarter of a century has enabled astronomers to extend their researches beyond any point which was formerly possible. Especially is this true in the case of double and binary stars.

The number of double stars has been so greatly increased during late years that their systematic measurement is a problem that ought to receive due consideration from astronomers possessing large telescopes.

If the observatories which have a large refractor, but are not specially interested in double-star work, could be induced to take charge of the observation of a limited number of the very difficult pairs, I think it would be time well spent, and would not seriously interfere with other systematic work.

A short time since I received a letter from Professor S. de Glasenapp, Director of the Imperial Observatory, St. Petersburg, in relation to methods of double-star observation, and suggesting that we ought to have more frequent observations of known or suspected binaries, and that double-star observations generally should be more evenly distributed.

Professor Glasenapp suggests that two observations in any year, made in different positions of the telescope, should be the minimum number secured.

It has been shown that an object-glass, in which the diffraction rings are not symmetrical, gives rise to an appreciable error, both in position angle and distance, owing to the unsymmetrical images. I do not think, however, that this source of error would be material with a good telescope when only moderate powers are employed.

In case measures could always be made near the meridian there would be no difficulty in conforming to this rule. But in the case of very close or otherwise difficult pairs, in order to get measures at all they must be made whenever one can get an exceptionally good night.

In our climate and in the United States generally, with perhaps the exception of the Pacific coast, there are very few extra fine nights in a year.

I think myself, in general, two observations would be sufficient to guard against accidental error. The systematic errors of different observers would usually be much greater than that due to unsymmetrical images,

and hence I do not consider the reversal of the telescope to be of paramount importance.

It has occurred to me that if some arrangement could be made among double-star observers, something in the nature of a division of labor, very much more could be accomplished and there would be less useless duplication of observations.

The number of interesting double stars is now so great that no single telescope could furnish measures except after a considerable interval.

There are now in the United States and Europe eight very large refractors and a host of moderate size from a six-inch object-glass upwards.

The great telescopes ought to give especial attention to the difficult work, and leave what is easy to the smaller instruments.

It seems to me a waste of energy to do systematic work with an object glass of eighteen inches aperture that could be done equally well with one of six inches, especially as there are so many problems in astronomy which need all the optical power that is at our command.

The number of known double stars, which are worthy of systematic measurement, may be placed at about 3500; perhaps only a small percentage will prove to be binaries, but the micrometrical measurements would be of value in determining proper motion.

Of this number a six-inch object-glass is able to deal successfully with more than one-half, leaving about 1500 pairs for the larger telescopes.

There are two classes of double stars which are difficult to measure:

1. When the components are excessively unequal in magnitude but not especially close, of which Sirius has been a good example.

2. When the components are nearly equal in magnitude, but excessively close in distance of which class $\theta\Sigma 535 = S$. Equulei may serve as an example.

Under the first class there are many pairs in which the magnitudes are unequal and at the same time very close in distance. The binary A. G. C. 13 = τ Cygni is a good example.

In my own experience the unequal pairs are more difficult to manage than the excessively close equal pairs.

The great catalogue of measures by Baron Dembowski shows what a 6½-inch object-glass can accomplish when used by a trained eye.

For pairs under 1", however, a small aperture appears to give the distance too large; and I think the same is true for any aperture, when a low power eye-piece is used.

In his catalogue for 1880, Mr. S. W. Burnham gives the total number of known pairs having a distance less than 1" at 579. The discovery of new pairs since that time at Madison, Lick and including my own at Chicago would make the total numbers of pairs now known under 1" of distance, at about 800.

An equal pair having a distance of 0".5 is not necessarily a difficult object for a large aperture. But when the distance is only 0".4 or less, it is not an easy object at any time with the 18½-inch.

Excluding binaries, in which the semi-major axis is more than 0".5, there are now about 120 pairs in which the distance is less than 0".5. As a large

percentage of this class ought to prove to be binary systems, they should be observed as frequently as possible. To do this would require the co-operation of astronomers having large refractors. In the measurement of close pairs, *viz.*, $0''.8$ or less, in my own case, the distance obtained by using the micrometer is perhaps no better than a mere estimation, and hence observations by different observers would be especially valuable for stars of this class.

The thickness of my micrometer wires is approximately $0''.8$. Now unless the wires are sufficiently separated to see light between them, one may turn the screw head back and forth and get any numerical result between 0 and the thickness of the thread.

The theoretical separating power of our telescope, according to Dawes' formulæ is $0''.25$. I have never seen so close a pair separated. I think, for my eye, the limit of discrimination, as to whether a star is double or not is $0''.2$, for nearly equal pairs. In such a case, the disk of the star is seen slightly elliptical.

With a larger aperture, like the Lick, in which the primary image is twice as great, the limit of discrimination might be as small as $0''.1$.

The discovery of new pairs worthy of a place in a catalogue has become a much more difficult matter than it was a few years ago.

Following the elder Struve, Otto Struve with the 15-inch refractor of the Pulkova Observatory added 547 pairs to those already known; the Cincinnati Observatory, under the direction of Prof. Ormond Stone, has contributed about 200 new pairs; Mr. S. W. Burnham, observing with various instruments, has added 1154 pairs; and my own catalogue now comprises about 400 pairs.

Among the naked-eye stars, brighter than 5th magnitude there is but little chance of finding anything new with an $18\frac{1}{2}$ -inch aperture; but among the 6th, 7th and 8th magnitudes there yet remains undiscovered a large number of close and equal pairs.

North of the equator, but comparatively few equal pairs are uncatalogued in which the distance exceeds $0''.5$. In my experience, I find two pairs to be new when the distance is less than $0''.5$ to every one pair which is new when the distance is between $0''.5$ and $1''$.

Among the naked-eye stars, future discoveries will mostly be of the class in which the companion is faint and at the same time in close proximity to the principal star. Discoveries of this class can only be made by the use of a high magnifying power and large aperture.

The employment of a high power is very inconvenient in practice, as the apparent rapid diurnal motion seriously interferes with critical seeing.

The identification of suspected new pairs becomes a tedious and uncertain matter. If one is compelled to examine all double-star catalogues.

About four years ago it occurred to me that a double-star index could be prepared without very great labor, which would enable one at a glance to identify any known pair. After trying a number of forms, more or less complete, I decided on the following which is found of great value in whatever relates to double-star observations.

Ruled sheets were prepared with the hour and multiple of 5 m. in R. A.

printed at the top. Under each 5 m. heading of R. A. there are three vertical lines dividing the space unequally.

The following specimen will indicate the form of the Index.

21 H.

30 M.			35 M.		
	DEC.	CAT. MAG. DIST.		DEC.	CAT. MAG. DIST.
S ₇	+ 55° 14'	β 680 $\frac{8}{8}$ 117° 0'' .4	5 ₄	+ 42° 44'	A. C. 20 $\frac{6}{11}$ 823° 2'' .2
S ₈	+ 20° 11'	OZ 445 $\frac{8}{9}$ 109 1''	5 ₇	+ 28° 48'	OZ 448 $\frac{8}{9}$ 243° 0'' .7

The first column is for odd min. of R. A.; second, declination; third, Cat. Numb., magnitude, position angle and distance. The magnitudes, position angle and distance are given in fractional form.

The index formed on this plan requires ninety-six pages of foolscap, three columns to the page, which leaves about one-third of the space blank for the insertion of new pairs.

My Index contains all of $\Omega\Sigma$, β , The Clarks, Madison, Cincinnati, Herschel and South which have been measured, miscellaneous pairs, Σ under 2'' of distance, and my own. By means of this Index, one can identify a known pair in a minute or two.

It also shows at a glance, what doubles are in the immediate vicinity. It quite frequently happens that two or more doubles are in the field of the finder at the same time; one of which may be a new pair.

Any one engaged in making systematic measures would find such an index of great value in selecting the stars to be measured.

In the micrometrical measurement of double-stars, we have found it convenient to place each pair on a separate slip of paper, having the hour of Right Ascension conspicuously stamped at the top. These slips are arranged in packages for each hour of R. A. Whenever a pair has been observed two or three times, the slip is removed from the package. By this method one can see at a glance what pairs require to be measured.

A METHOD OF TESTING FOR PRIMES. BY JAS. D. WARNER, Brooklyn, N. Y.

[ABSTRACT.]

ARRANGING the equation of quarter squares into the form $A^2 - B^2 = N$, where N is a number whose terminal figure is 1 or 9. When the terminal figure of any number is 3 or 7, it may be brought under this limitation by multiplying it by any number whose terminal figure is 3 or 7.

Principles relating to values of A and B.—Either A or B is divisible by 2, 3 or 5; each divisor being considered separately. And A or B is divisible by 8, according as the excess over a multiple of 3 is 2 or 1.

One of the squares being divisible by 9, the other square will have an excess over a multiple of 9, which is the complement of 9 over a multiple of 9 in N. The root of the latter square for an excess of 1 or 8, will have an excess of 1 or 8; for an excess of 2 or 7, an excess of 4 or 5; for an excess of 4 or 5, an excess of 2 or 7.

Principles relating to squares.—In any square the figure preceding the terminal figure is even, unless the terminal is 6.

For any termination (last two figures) of a square, except 00 or 25, there are two sets of values for the terminations of roots. Each set has two values, which are complements of 100. The sets are related to each other, in having a termination in one differ from a termination in the other, by 50. The sets will be termed congeners. A termination of a square determines the congeners for that termination.

The character of s (second figure preceding terminal being odd or even) is determined from the root by simply squaring the last three figures.

Value of s.—When any root terminates with 5, the termination of the square is 25, and s is 0, 2 or 6, according as the root varies from a multiple of 50, by 5, 15, or 25. The character of t (third figure preceding terminal) is odd or even, according as s in the root is odd or even, when the termination is below 50, and reverses in character when the termination is above 50. When the termination is 85 or 65 the rule is reversed: exceptions, 55, 85 and 95.

For 05; $t = s$; and equals $9 - s$ for 95.

Value of For 55; $t = s + 3$; and equals $9 - s + 3$ for 45.

t from root. For 15; $t = 3s$; and equals $3(9 - s)$ for 85.

For 65; $t = 3s + 4$; and equals $3(9 - s) + 4$ for 35.

For 25; $t = 5$ or 0, agreeing in character with s, and with $9 - s$ for 75.

For 05; $f = t + s^2$.

For 95; $f = -t + (s + 1)^2 - 1$.

For 55; $f = t + s(s + 1)$, for first 7 digits; add 1 for last 3.

For 45; $f = -t + s(s + 1)$, for first 3 digits; add 1 for last 7.

For 15; $f = 3t + s^2$, for first 4 digits; add 1 for each set of 3 digits above.

For 85; $f = 3t + (s + 1)^2 - 3$, for last 4 digits; add 1 for each set of 8 digits below.

For 65; $f = 3t + s(s + 1)$, for first 2 digits; add 1 for next 4; 2 for next 3; and 3 for 9.

For 35; $f = -3t + s(s + 1) - 3$, for last 2 digits; add 1 for next 4 below; 2 for next 3 below; and 3 for 0.

For 25; $f = 5t + s^2$, for first 2 digits; add 1 for each couplet above.

For 75; $f = 5t + s(s + 1)$, for first 3 digits; add 1 for each couplet above; and 4 for 9.

Value of f (fourth figure preceding terminal)
from root.

Method.—Since A^2 or B^2 must have the termination 00 or 25, the first

proceeding is to test each by addition or subtraction of termination of N , and find the termination of the other square. In each case find proper values for s to precede the congeners of the termination of each of the latter terminations, so that 0, 2 or 6 may precede the termination 25, or a proper terminal for a square may precede the termination 00. Use only those roots which are, or are not, divisible by 3, according as the square, not divisible by 5 is or is not to be divisible by 9. The squares of these roots, for the several congeners, are to be placed over N , in separate columns, for addition to it, when the square not divisible by 5 is B^2 . When this square is A^2 the above values of the roots are each to be increased by a multiple of 3000, till the square exceeds N . This square is to be placed over N for subtraction.

After forming the heads of the columns, add or subtract N . If R (the result) be not a square, add continuously a constant C to D_1 , to obtain D_2 , D_3 , etc., which are to be added cumulatively to R , till a sum is obtained that is a square or exceeds N . If no square be found, N is a prime. The D 's are the first differences, between the squares of the roots r , in order, varying generally by $8b \cdot 10^a$, which have a certain number of unchangeable figures a at the end ($a=3$ generally), $D_1 = 6hr \cdot 10^a + 8b^2 \cdot 10^{2a}$; $C = 2 \cdot 8b^2 \cdot 10^{2a}$; and the sum is equal to $3^2 b^2 n (n-1) \cdot 10^{2a} + D_1 n \cdot 10^a + R$. The least value of C is 18000000.

$$\begin{array}{rcl}
 \text{Example:} & 685584 = 828^2 \\
 & \underline{215656441} = N \\
 0828 & 216342025 = R \\
 & \underline{13968} = 6 \times 828 + 3^2 \cdot 10^3 = D_1 \\
 8 & 280310 \\
 & \underline{31968} = D_1 + 18 \cdot 10^3 = D \\
 6 & 262278025 = 16195^2
 \end{array}$$

Special cases where C is large.—If 0 be a proper value for s , to precede the termination 00, t must also be 0, C will be 9 billions, and will be increased 100 times for each duplicate set of zeros similarly obtained. If 5 be a proper value for s , by observing the various values of t and f , pertaining to squares of roots, with terminal 5, C will be very largely increased.

If the square with 00 or 25 is to be divisible by 9, the root of the square over N must have an excess or deficiency of 1, 2 or 4, so that R will be divisible by 9. C will be increased 3 times.

When N has an excess of 2 over a multiple of N , the square over N and the D 's are much larger, than when N has an excess of 1. When N has an excess of 1, a number may be obtained, having an excess of 2, for testing, by multiplying N by 11, 29, or any number having an excess of 2. Also, if desired, the terminations 00 and 25 may be interchanged by a multiplier 29, 41, 49 or any number with an even number preceding the terminal 1 or 9. These principles can be applied in elevating any number with a terminal 3 or 7, to one with a terminal 1 or 9.

In testing after obtaining R and four sums, the work can be used as a matrix for making 5 separate columns, when another figure will be unchangeable and C will be increased 25 times. After obtaining ten sums, in each of these five columns, they may be used as matrices, for forming ten columns, and C will be increased to 450 billions, at least.

In operating, the several columns should be carried along together, so that nearly equal sums may be obtained successively.

In protracted search, I propose to work downward from the upper limits, by using several principles, obtained from equations involving $\frac{1}{4}(N \pm 1)$, and also to test the sums obtained where the table of squares is not sufficiently extended. Also I propose a system of abridged multiplication for finding the unchangeable part of roots, where a table of squares is not available.

APPLICATION OF THE METHOD OF THE LOGICAL SPECTRUM TO BOOLE'S PROBLEM. By A. MACFABLANE, Prof. of Physics, University of Texas, Austin, Texas.

PROFESSOR SCHROEDER of Karlsruhe, by the publication of his "Verle-
sungen über die Algebra der Logic," has brought this branch of mathematics more generally to the notice of mathematicians. One of the problems he discusses is one which Boole proposed and solved as a specimen of the power of his method (*Laws of Thought*, p. 146). Boole says at the end of his investigation that he has not attempted to verify his conclusions. I propose to solve and verify by the method of the logical spectrum. The problem is:—

"Let the observation of a class of natural productions be supposed to have led to the following general results:—

(1) That in whichever of these productions the properties A and C are missing, the property E is found, together with one of the properties B and D , but not with both.

(2) That wherever the properties A and D are found while E is missing, the properties B and C will either both be found or both be missing.

(3) That wherever the property A is found in conjunction with either B or E , or both of them, there either the property C or the property D will be found, but not both of them. And, conversely, wherever the property C or D is found singly, there the property A will be found in conjunction with either B or E , or both of them.

Let it then be required to ascertain, first, what in any particular instance may be concluded from the ascertained presence of the property A , with reference to the properties B , C , D ; also whether any relations exist independently among the properties B , C , D . Secondly, what may be concluded in like manner respecting the property B , and the properties A , C , D ."

His answer to the former question is, "In whatever substances the property *A* is found, there will also be found either the property *C* or the property *D* but not both, or else the properties *B*, *C* and *D* will all be wanting. And, conversely, where either the property *C* or the property *D* is found singly, or the properties *B*, *C*, and *D* are together missing there the property *A* will be found. It also appears that there is no independent relation among the properties *B*, *C* and *D*."

His answer to the latter question is :

"If the property *B* be present in one of the productions, either the properties *A*, *C* and *D* are all absent, or some one alone of them is absent. And, conversely, if they are all absent, it may be concluded that the property *A* is present. And if *A* and *C* are both present or both absent, *D* will be absent quite independently of the presence or absence of *B*."

The method of the logical spectrum enables us to derive and verify these conclusions with facility.

Let *U* denote the class of natural productions, *a* having the property *A*, *b* having the property *B*, *a'* without the property *A*, etc.; then the data are :

$$Ua'c' \{ 1 = e(bd' + b'd) \} \quad (1)$$

$$Uade' \{ 1 = bc + b'c' \} \quad (2)$$

$$U \{ a(b + b'e) = cd' + c'd \} \quad (3)$$

In order to find *a* in terms of *b*, *c*, *d*, we suppose the whole class *U* subdivided into the sixteen possible classes formed by the presence or absence of *b*, *c*, *d*, *e*, and the three data particularized in succession by introducing the condition for a sub-class. Thus for the first sub-class we have :

$$Ubcdea'c' \{ 1 = e(bd' + b'd) \} \quad (1)$$

$$Ubcdeade' \{ 1 = bc + b'c' \} \quad (2)$$

$$Ubcde \{ a(b + b'e) = cd' + c'd \} \quad (3)$$

Now (1) gives no information, since *c* and *c'* are contradictory; and (2) similarly, because *e* and *e'* are contradictory; but (3) gives *Ubcde* (*a* = 0) that is, *Ua* totally excludes *Ubcde*.

Again for the second sub-class :

$$Ubcde'a'c' \{ 1 = e(bd' + b'd) \} \quad (1)$$

$$Ubcde'ade' \{ 1 = bc + b'c' \} \quad (2)$$

$$Ubcde' \{ a(b + b'e) = cd' + c'd \} \quad (3)$$

Now (1) gives no information, while (2) gives

$$Ubcde'a \{ 1 = 1 \}$$

which is indefinite; and (3) gives *Ubcde'* (*a* = 0).

This process simplified leads to the rule: Substitute 1 or 0 for each letter in the given equations, according as it enters directly or contrarily in the expression for the sub-class. Each equation will then be definite, indefinite or impossible, and if definite will give either *a* = 1, or *a* = 0. If

all the equations are indefinite, then a contains an indefinite portion of that class. If the only definite value for a is 1, then a contains the whole of that class; if 0, then none. If one equation gives $a=1$ and another $a=0$, then that class must be impossible.

By this method we get for a :-

$bcd'e$	none	$b'cde$	none
$bcd'e'$	none	$b'cde'$	none
$bcd'e$	all	$b'cd'e$	all
$bcd'e'$	all	$b'cd'e'$	impossible
$bc'de$	all	$b'c'de$	all
$bc'de'$	impossible	$b'c'de'$	impossible
$bc'd'e$	none	$b'c'd'e$	impossible
$bc'd'e'$	impossible	$b'c'd'e'$	all

Hence $a = bcd'e + bcd'e' + bc'de + b'cd'e + b'c'de + b'c'd'e'$, and by taking into account the impossible terms e and e' may be eliminated by addition, thus $a = cd' + c'd + b'cd$.

If we consider the elimination of e from the impossible terms, we find that the result is entirely indefinite. This is the answer to the first question.

To answer the second question, we form the sub-classes, due to the presence or absence of a , c , d , e , and by solving for a we obtain :

$acde$	impossible	$a'cde$	indefinite
$acde'$	impossible	$a'cde'$	indefinite
$acd'e$	indefinite	$a'cd'e$	impossible
$acd'e'$	all	$a'cd'e'$	impossible
$ac'de$	indefinite	$a'c'de$	impossible
$ac'de'$	impossible	$a'c'de'$	impossible
$ac'd'e$	impossible	$a'c'd'e$	all
$ac'd'e'$	none	$a'c'd'e'$	impossible

Hence, $b = a'cd' + \text{an indefinite portion of } (acd' + ac'd + a'cd)$ and there is a relation independent of b , namely :

$$acd + a'cd' + a'c'd = 0$$

These are the analytical expressions for Boole's second answer.

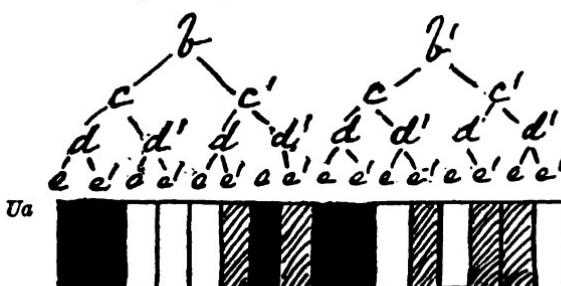


DIAGRAM 1.

The diagrammatic verification is as follows:—Let a strip represent U , the whole collection of productions. In diagram (1) Ua is represented by

the white part of the strip; Ua' by the black, and the non-existent part by the shaded. Similarly diagram (2) represents Ub . It will be found on

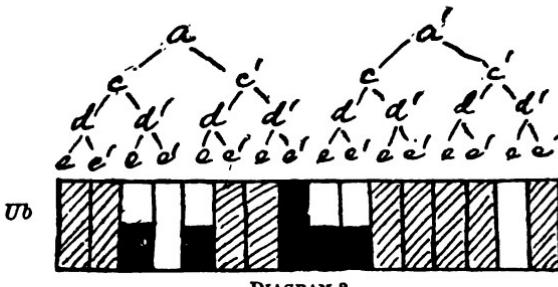


DIAGRAM 2.

trial that these values of Ua and Ub are the most general values, satisfying the given data; and it also appears that the second datum is imaginary, for the subject Uad' does not exist.

A NEW SELF-REGISTERING PHOTOMETER. By J. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THIS paper gives a brief description of a new automatic self-registering photometer which allows the use of about 70 per cent of the light for comparison, and the percentage of light can be read at once when being compared with a standard or other source of light. It is particularly useful when it is desired to compare the value of a transient source of light, such as the light of the corona during a solar eclipse.

RECENT STUDIES IN THE ULTRA VIOLET SPECTRUM. By J. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THIS paper refers to some recent studies in the ultra violet spectrum, with a Rowland grating, showing that while the limit heretofore reached was at about wave length 2100, two sharp lines are now shown in the spectrum of aluminum, at $\lambda = 1860$ and 1862.

THE GREAT "LICK" SPECTROSCOPE. By J. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THIS paper gives a brief description of the great Lick spectroscope, and includes some notes on a proposed spectroscope for the Halstead 28-inch refractor.

RECENT PHOTOGRAPHS OF THE MOON BY DIRECT ENLARGEMENT. By J. A. BRASHEAR, Allegheny, Pa.

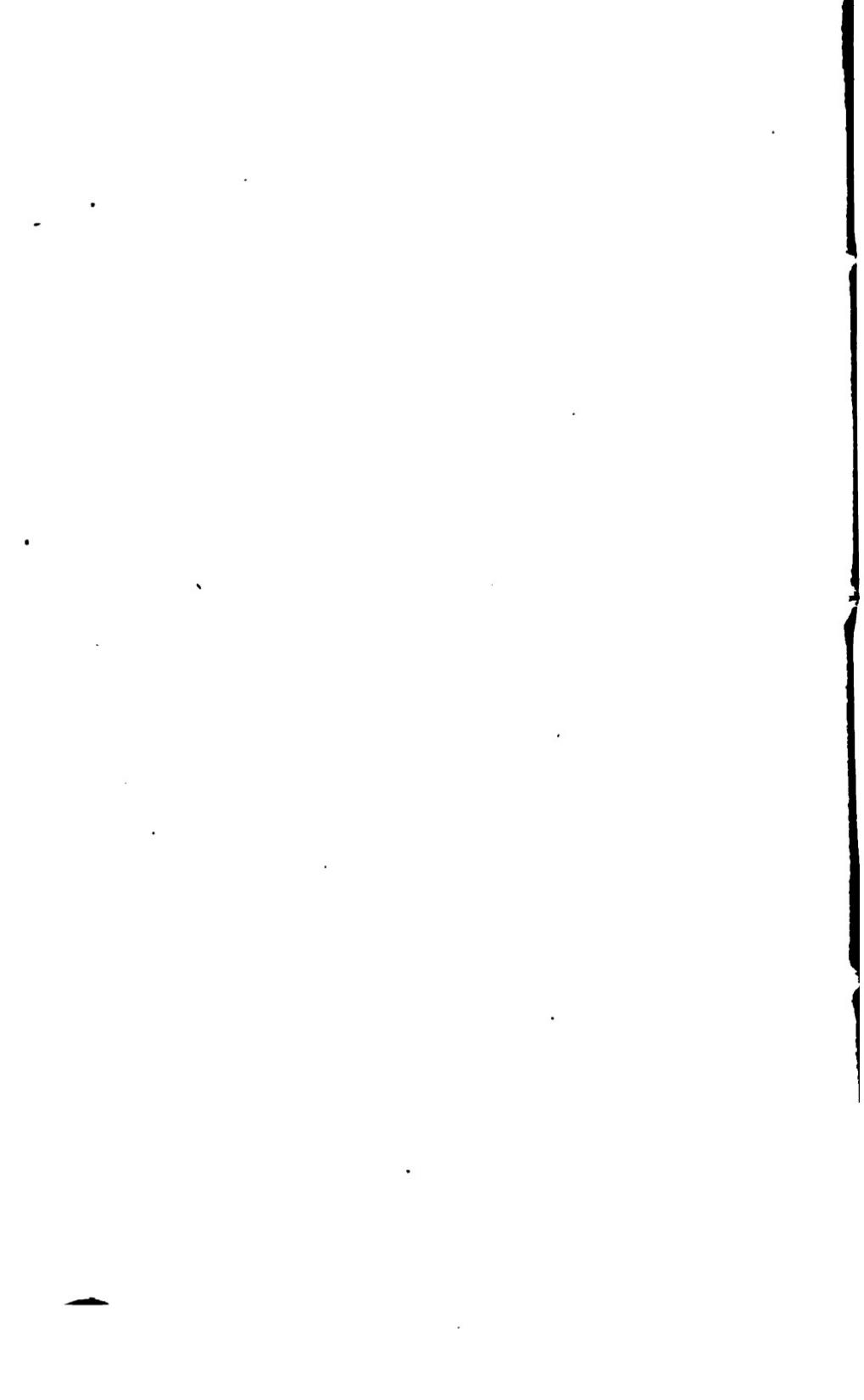
[ABSTRACT.]

NOTE on some recent photographs of the moon by direct enlargement in the telescope. Three photographs taken by M. M. Paul and Prosper Henry of the Paris Observatory.

SOME PERSONAL EXPERIENCES ON THE EXPEDITION TO CAYENNE, FRENCH GUIANA, TO OBSERVE THE ECLIPSE OF DEC. 22, 1889. By CHAS. H. ROCKWELL, Tarrytown, N. Y.

THE PROBLEM TO CIRCUMSCRIBE ABOUT A CONIC A TRIANGLE WHICH SHALL BE INSCRIBED IN A TRIANGLE WHICH IS ITSELF INSCRIBED IN THE CONIC, AND A CERTAIN QUESTION CONCERNING TWO BINARY CUBICS. By ELIAKIM H. MOORE, Evanston, Ill.

A THEOREM OF PLANE CUBICS. By Prof. FRANK H. LOUD, Colorado College, Colorado Springs, Col.



SECTION B.

PHYSICS.

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ADDRESS

BY

CLEVELAND ABBE,

VICE PRESIDENT, SECTION B.

DELIVERED BEFORE A JOINT SESSION OF SECTIONS A AND B.

A PLEA FOR TERRESTRIAL PHYSICS.

COLLEAGUES AND FRIENDS : It gives me great pleasure to welcome you to the annual gathering of the Physical Section. This event is one to which all look forward from year to year, because of the inspiration and energy that come from personal intercourse with those who are fresh from laboratories and observatories. Frequent communion with experimentalists is peculiarly valuable to those who lean too strongly to the study of theory, that is to say, those who are puzzling over problems that are still beyond them.

It is comparatively easy to evolve from one's inner consciousness ethereal forms analogous to the actual substances of the world around us, and to reason upon the properties of these creations of one's own imagination : but the conscientious student of Nature, the true physicist, abandons such idealizations as soon as he sees them to be inconsistent with observed phenomena, and abides by the study of his experiments until they suggest to him some truer view.

And thus we come to-day to greet each other, the theorist, the physicist, the mathematician ; for physics and mathematics are associated quite as closely as astronomy and mathematics.

In the subdivision of our society into sections, and as an expression of 8,000 years of past history, the first place has by courtesy been given to the conjunction of mathematics and astronomy, as if there were a necessary connection between the two, whereas in

truth, the coördination of mathematics and physics would have been equally and eminently proper; probably before many years we shall also realize that mathematics and chemistry have a similar intimate association. Fourier, Gauss, Green, Poisson; Helmholtz, Stokes, Kirchhoff; Sir William Thomson, J. J. Thomson, Maxwell, Rayleigh, Darwin, Willard Gibbs and many others have introduced mathematical formulæ into the study of terrestrial and molecular physics quite as successfully as did Newton or La Place introduce such formulæ into astronomy. Mathematical physics will always be as welcome as experimental physics in this Section "B." In fact, a most important subdivision of our section, that of terrestrial physics, must always deal largely in mathematics since it is essentially an expansive application of laboratory studies in molecular physics.

This brings me to the question, what range of subjects may properly be treated under the general heading "Phyeics?" I confess that this single, short word has to me a broad significance that is delightful to contemplate, since it embraces the study of the recondite causes of all phenomena, wherein force or energy is involved. Thus we have celestial physics, terrestrial physics, molecular physics. The ordinary collegiate usage restricts the term "physics" to the last mentioned special field of study, but as the Constitution of our Association assigns astronomy and mathematics, and therefore by implication celestial physics to Section "A," it has been decided that both terrestrial and molecular physics belong to Section "B."

It is impracticable to draw hard and fast lines defining the limits of the sections of our respective sciences; it is unnecessary here to promulgate an imperfect human system of classification that shall embrace the whole divine universe; I take it, that those who in this section so generally devote themselves to the physics of the laboratory will fully appreciate the broader problems offered by the application of their microcosmic studies to the general phenomena, the macrocosmics of the globe on which we live.

The published literature of the past year, as well as the papers offered to be read at this meeting, show how vigorously researches in mechanics, chemistry, electrics, thermotics, acoustics and optics are being prosecuted by the aid both of mathematics and of experiments, but on the other hand, we are impressed with the fact that progress in terrestrial physics has continued to be as slow, as diffi-

cult and as laborious, and almost as discouraging as in former years. This, however, is to be expected so long as our best students find the grander terrestrial problems more difficult and less interesting than the minor problems. Of course we must proceed in our scientific course from the easy to the more difficult. Science is now busy with electricity, and it may not yet be the age to expect the true solution of questions bearing upon terrestrial physics. Must these then be deferred to another century? Granted that we still know too little about the phenomena and substances that we can deal with in our laboratories, yet surely this latter study has already progressed far enough to justify spending some small percentage of attention upon the simpler outlying problems that our globe offers to us. Here, as in every other department of natural science, a voice whispers, "man is put here to study and conquer Nature. Make her subservient to your wants. Go up into the land and possess it."

I am therefore at this time about to venture upon a few words of intercession in behalf of the erection of institutions for, and the devotion of students to the prosecution of research in this broad and difficult, but highly important realm.

A PLEA FOR THE STUDY OF THE PHYSICS OF OUR GLOBE.

The problems specifically included under the terms terrestrial physics, or physics of the globe, embrace all those in which we consider the land, the ocean and the atmosphere respectively as units or as parts of the greater unit which the astronomer calls "the earth;" problems in which the phenomena depend more or less upon the size, the shape, the diurnal rotation and annual revolution of our globe, or upon the viscosity, the elasticity, the density and the mutual attraction of its parts. The phenomena to be studied are often of entrancing beauty, and always of such importance as to justify any mathematical or experimental physicist in spending time and labor upon their investigation.

Terrestrial physics is the study of the globe *upon which* we live as distinguished from the study of the matter *by which* we live; as the matter studied in molecular physics is a part of man, so man is a part of the globe. Man can alter the molecular conditions of food substances until he adapts them to the conditions of his own physiology, but he can not alter the greater terrestrial conditions surrounding him. He may experiment with earth and water and air,

but not with *the earth, the ocean and the atmosphere*; these he may only study and understand so as to adapt himself to them. The establishment of observatories, laboratories, schools and other institutions for the promotion of terrestrial physics will directly contribute to the advance of civilization by just so far as they contribute to an increased knowledge of the environment of the human race.

The present condition of mathematical, astronomical, chemical and molecular studies is traceable to the careful nurture of observatories and laboratories, and to the general instruction in these matters; the patrons of these sciences are the sovereigns and universities of the nations. But the number of those who have been free to devote themselves to either experimental or mathematical work in terrestrial physics is comparatively small, and their financial means still smaller relatively to the former class of workers. Could we see a corresponding attention given to the nurture of the latter, and a corresponding encouragement to students to devote themselves to this work, we should certainly see corresponding excellent results. But I will not stop at generalizations; let us glance particularly at some branches of our subject:

I. *Vulcanology*.—The most difficult problems are those relating to the condition of the interior of the earth and the reaction of that on the surface. The growth of our knowledge of these questions was ably set forth at our Toronto meeting by Mr. R. S. Woodward as vice-president of Section "A," and his historical sketch affords a fine illustration of the attention given by astronomers to physical problems; but astronomy and pure mathematics will alone never settle these questions; in the nature of things, they never can and I propose that they be relegated to the conjunction of astronomers with the experimental and mathematical physicists and chemists, and that means be provided for the study of terrestrial matter under high pressures and temperatures. It is possible, nay probable, that the internal heat of the earth is not necessarily so excessive as was formerly supposed, but certainly the internal pressure is vastly greater than is generally realized.

The fluidity of the earth's interior is due to pressure quite as much as to heat. Our globe is of the nature of a plastic and viscous mass, and this has sufficed to enable it to become spheroidal without the need of assuming that it once was a limpid fluid; give it time enough, and it will slowly assume any required shape, release the

interior masses from heavy pressure and they will become as rigid as we see them at the surface. The lava and trap disgorged from beneath the earth's surface may have given a wrong impression as to the general state of the deepest interior regions, for they come from moderate depths and their heat and liquidity may be in a great part the result of unknown chemical changes that slowly mature at moderate temperatures under enormous crushing pressures. We know little about the effect of such long continued temperatures and pressures, because they are beyond the reach of our present experimental researches, but I understand that an earnest effort is being made in this line of work by our Geological Survey.

In common with others, I have for years hoped that observations of terrestrial magnetism would give us some ideas as to the condition of the depths of the earth, but I shall in a few minutes show that we must give this up, so that we are forced to base all our hopes upon experimental work on the chemical and physical behavior of solids under great pressure and upon mathematical work on the laws of elasticity applicable to a large non-homogeneous mass of viscous matter such as is our so-called "solid" globe. The experimental work may be considered as already begun, and the mathematical work known as the theory of elasticity in viscous solids has been attacked by Clebsch, Maxwell and Saint Venant and their numerous followers.

II. *Geognosy*.—From the deeper depths hidden from touch or sight within the earth, we ascend to the surface or crust where a variety of important phenomena and problems present themselves. Have the general locations and features of the continents and the ocean beds always been as now? What is the mechanism of the rise and fall of mountain chains, and the crumpling of strata that once were horizontal? The phenomena, we observe, belong to geology, but their explanation belongs to geognosy and is a matter for experimental mechanics and physics.

It has already become evident that the steady action of great pressure upon hard solid rock will mould it like clay into all the forms that we have observed if only time enough is given. There is nothing known that is absolutely rigid; warmth, pressure and time change all things. A ball of glass is highly elastic, its molecules transmit the most rapid vibrations of the spectrum to give us light while its mass, struck by a hammer, vibrates less rapidly with a clear sounding note to give us the slower vibrations of

sound. But substitute a long continued pressure for this quick blow, and the glass becomes as permanently deformed as does the plastic clay. It is elastic to quick blows, but plastic to slow pressures. The experimental study of the relations of pressure, temperature and time, or the so-called "flow of solids" at ordinary temperatures, began recently and is now carried on by many. The temperature and the plastic deformations of our crust demand careful study. The experimental researches in mountain building by H. M. Cadell (*Transactions of the Royal Society of Edinburgh*, Vol. xxxv), and the deep bore temperatures by Dunker, are the latest contributions to these subjects, and much more of that kind of work remains to be done by special physical laboratories. Even the gas and oil wells of Indiana have their stories to tell in regard to their formation during the slow process of terrestrial crumpling. Why do we not study them? Is it for the want of money or for lack of opportunity?

The origin of these greatest crumpling pressures has long been debated, but in my next section I shall maintain that we are not to attribute this crumpling and mountain building in recent geological ages altogether to pressures resulting from contraction following on after the general cooling of the earth's surface. This cooling is undoubtedly a true cause and has afforded magnificent problems for Fourier and his followers, but it has become a less important cause as compared with another one, the evidences of whose existence are now everywhere apparent.

III. *Seismology*.—Our earth is subject to earthquakes that start with a shock and spread as a vibration far and wide. What are these shocks? In general it seems to me we must reply that the attractions of the sun and moon produce a system of strains within the earth; on the one hand, these strains cause a part of, or even the whole external crust, to sometimes slide a little about its viscous interior; on the other hand, these strains occasionally and systematically combine, so that the crust cracks and separates, or crumples and faults a little, and this operation is repeated accumulatively age after age until mountain chains and continents are formed. The specific day, when such cracks are likely to occur, is that moment when the sun and moon are in conjunction and in perigee. At that time, we have the greatest tidal strains; this condition endures for a day or two as the moon moves past the sun; during any day at the period of conjunction, the earth by its

rotation presents every side successively to the sun and moon and causes all its substance to pass through the region of greatest strain. Now our globe is not strictly homogeneous as to density, nor as to strength, and when its weakest great circle comes into the plain of greatest strain, there is a slight give, an earthquake, a fault, a dislocation of strata, a squeezing up of lava. Thus it goes on, age after age. The steady progress of crumpling is due not so much to cooling as to the pressures periodically accompanying slow tidal action in the viscous solid globe itself.

The dependence of the earthquakes of the Pacific Ocean on the sun and moon is shown by statistics. The great circle of the Andes, Rocky Mountains and Eastern Asia marks the principal plane of weakness of the earth's crust during the present geological age. This divides the great depressions of the bed of the Pacific Ocean from the elevations of Europe, Asia, Africa and America, or as the physical geographers say, it divides the land from the water. A very similar set of strains, in the body of the moon, has given her surface a bulge and a series of ridges that are admirably prominent to the naked eye.

Doubtless in other geologic periods other planes of greatest weakness may develop; probably in early ages, our crust may have yielded more frequently than now to special strains produced at every conjunction or opposition of the sun and moon, but for a long time past, the principal yieldings have been those which occurred when sun and moon were in perigee, and in this way has been brought about that remarkable configuration throughout the world of mountain ranges and coast lines that trend in circles tangent to the Arctic and Antarctic circles.

The pressure due to luni-solar tidal strains is a more potent factor and a more systematic agent in producing sliding and crumpling than that due to contraction by cooling. But the motions of the strata are liable to be spasmodic, and the earthquake shocks become earthquake vibrations that run over large portions of the earth's surface; the study of these vibrations may properly be expected to enable us to trace each to its origin, and thus show us the depth to which the tidal strain is effective. Below this depth it is evident that a species of rock welding goes on, the rocks under great pressure and moderate heat weld into one continuous plastic mass. This stratum of welded rock is the extreme limit of the earth's crust.

The new electro-welding process suggests special methods for studying the exact temperatures and pressures (and therefore the exact depth in the earth) at which rock welding takes place. The study of earthquakes and vibrations is a fundamental problem for any institution devoted to terrestrial physics. I have for many years quietly labored to stimulate the observation and active study of these phenomena, and hope that this American Association, like that of Great Britain, will foster an interest therein.

IV. Axis of rotation.—The earth's axis of rotation coincides very closely with its axis of maximum inertia, viz., its shortest polar diameter or "principal axis." So long as these exactly coincide, our latitudes and longitudes will be constant, anything that causes the axes to differ will introduce a slight periodic change of latitude and longitude due to the revolution of the instantaneous axis of rotation about the principal axis of inertia. If the earth were a perfectly rigid or perfectly elastic mass, this periodic change would continue indefinitely; but as the earth is a viscous mass, it will slowly accommodate its figure to the new conditions; it will stretch a little with each rotation about the instantaneous axis of rotation and will flatten out a little more at the poles and finally settle down to permanently steady rotation around a new, permanent or sub-permanent axis of maximum inertia situated between the new axis of rotation and the old axis of maximum inertia, with a new rate of rotation a little slower than before. Thus it happens, as it seems to me, that principally through the action of the sun and moon, producing geological orographic changes in the crust of the earth, our latitudes have small periodic changes, dying away to a period of constancy or rest, followed by a new set of changes and again a period of rest, while on the whole the day is slowly lengthening, all of which would not occur were the earth perfectly elastic or perfectly rigid. This process will continue until our equatorial bulge is as large as the sun and moon and centrifugal force combined are able to maintain against the levelling force of terrestrial gravity. Our globe may not be old enough to have as yet attained its maximum bulge.

The astronomers were the first to suspect the existence of these movements, and their reality is now beginning to be acknowledged; it remains for the physicist and the student of elasticity to show the meaning of the terrestrial movements that trouble the delicate measurements of astronomy and geodesy and to deduce the gen-

eral average coefficient of the viscosity of our globe. We may even be able to elucidate the process of disintegration by which Saturn's rings were formed.

V. *Gravitation*.—The attraction of the earth as a whole for other objects has long been a favorite subject of observation and study. The time of vibration of the ordinary pendulum gives us the means of measuring the relative force of gravity at different points. Simpler instrumental means are desirable, and the physicist must supply them if he can. In the pendulum, gravity is opposed to the inertia of the mass of the pendulum. In the spring balance, gravity is opposed to the elasticity (or more exactly to the inertia of the molecules) of the metallic spring, whose temperature is far above that absolute zero where there can be no elasticity. In the horizontal pendulum and the torsion balance we have the means of measuring attractions by methods parallel in principle to the two preceding respectively. A fine series of determinations of gravity, such as those made for the Coast Survey by Mr. E. D. Preston on the recent eclipse expedition under Prof. D. P. Todd, is an important contribution to the general question of the attraction of islands and oceans relatively to that of the whole earth. But a minute pendulum survey of the territory of the United States, especially of the mountain chains, is now very desirable. Every one will recognize that such determinations of gravity form an important branch of terrestrial physics. Will not some one devise a sufficiently delicate form of spring balance to replace the laborious pendulum?

VI. *Terrestrial magnetism*.—There is no more mysterious yet practically useful force than the so-called terrestrial magnetism. Strange that we should know so little about that which is daily manifest to us! When we handle a bar of magnetic iron, we know that although we do not understand what magnetism is, yet at least we can say that it exists within this bar. Now the earth acts like a great magnet, but yet we dare not say it is a magnet; we even hesitate to reason upon the general hypothesis that Gauss assumed in his *Theoria*, *i. e.*, that it has magnetic matter distributed irregularly throughout it. The fact is, the recent work on recalcescence shows that at a temperature of 690° Centigrade, iron and steel cease to be magnetic. Now that temperature must be attained at a depth of 27,500 metres, if the earth's temperature goes on increasing downward at the rate of 25° Centigrade per thousand

metres as found by Dünker in the bore at Sperenberg; or at the depth of 25,500 metres if the rate of increase is 27° Centigrade as found by him at Schladebach. Therefore, all magnetized iron must be within a thin outer crust that is scarcely twelve miles deep. But Gauss showed that the average magnetism at the surface of the globe corresponds to the distribution throughout its whole interior of seven one-pound steel magnets per cubic metre. If this magnetic force is to be all confined to the outer thin crust, then the average magnetic charge must be one hundred times greater per cubic metre; but this is preposterous, and we must conclude that either the interior of the earth has not this high temperature, or else the material of the earth is not truly magnetic, viz., no more so than is the copper wire that conducts a current around an electro-magnet and which coil in fact has all the properties of a magnet without being one. The latter alternative we can easily adopt, but we have still to demonstrate the origin of the electric current that circulates around the globe and makes it an electro-magnet.

The observers and the students of terrestrial magnetism are numerous, but Nature still holds fast her secret and in this field of investigation we especially need the best talent in mathematical and experimental physics. I may, however, indicate the fact, that apparently one feature of the subject has been unriddled, viz., the systematic, diurnal, annual and twenty-six-day perturbations and also the irregular storms. This is the work of our colleague, Professor Bigelow of Washington, who has published a synopsis of his recent studies in a bulletin of the eclipse expedition to the west coast of Africa. He finds these perturbations fully explained qualitatively and we hope quantitatively also by considering the action of a conducting globe within a non-conducting atmospheric envelope, or dielectric, the whole rotating diurnally and revolving annually in a field of electric force such as must proceed from the sun concurrently with that other influence that gives us light and heat as its effects on our senses.

Thus much for the perturbations, but the main phenomenon, the subpermanent magnetism, is still unsolved, though I think the most plausible view is that the tidal strains that we have already had to consider produce a steady supply of piezo-electricity that manifests itself in ground currents and terrestrial electricity, the flow of which is mainly from east to west and converts our earth into an electro-magnet. This conclusion forced itself upon me in 1888

or early in 1889, but now seems to have been long since arrived at by no less an authority than Clerk Maxwell, whom I most unexpectedly find to have suggested it in the second volume of his "Treatise on Electricity."

VI. Oceanology.—The relations between the ocean and the land as well as the special phenomena of the ocean itself, offer a new series of problems to be studied, of which we would especially mention those relating to tides and currents and deep sea temperatures. The researches of the Challenger expedition and those of our own Coast Survey and Navy have opened to wondering eyes an unknown world in the depths of the sea.

Now the average temperature of the ocean bottom is but a little more constant than the average temperature of the surface of the land, therefore, so far as the conduction of heat is concerned, the interior of the earth gives up no more annually to the sea than it does to the atmosphere, *i. e.*, sufficient to melt one-fourth inch of ice per annum; therefore the ocean beds have not been formed by special cooling processes; in fact the theory of contraction by cooling entirely fails to account for the formation of the great watery hemisphere of our globe with its centre at the antipodes of London. This great deformation of what was once a more perfect spheroid is undoubtedly the work of those insidious lunar and solar tidal strains above alluded to and the same mathematical analysis that in the hands of Darwin deals with these strains has at the hands of Rayleigh dealt with the tides of the great watery oceans. The ocean and the earth beneath it differ only in quality, not in kind; they are both viscous, yielding masses.

From the great tidal waves we pass to the long earthquake waves that cross the Atlantic and Pacific and through the great storms waves come still further down to the ordinary short swell of the ocean; each of these classes of waves offers an important field of study. Probably no more magnificent illustration of the interference of waves can be found than is shown in the phenomenon of "The Rollers" and "Double Rollers" of the Islands of Ascension and Saint Helena. The recent "Eclipse Expedition" afforded an admirable, almost unique opportunity to perceive the nature of this dreaded phenomenon in that from a high hill I found myself looking down upon a wide expanse of ocean covered with intersecting systems of swell deflected around both sides of the island and intersecting on the leeward shore. Such problems as these on

ocean waves can not easily be studied in a permanent laboratory, but the experimental results obtained there should be verified by sending the experimenters to the localities where they are best developed.

VII. *Meteorology.* Our atmosphere is a part of our earth. It is included in its mass when the astronomer speaks of the mutual attractions of the earth, the sun and the moon ; it is the most important factor in our geological history ; it is also the most important factor in the existence of man. He may live forty days without food, but not forty minutes without fresh air. The phenomena of the atmosphere generally take place on too large a scale to be called local. A large region of the atmosphere is affected by every storm. The winds carry the seeds of plants and the germs of disease from one continent to another. The droughts and floods, the heat and cold of America depend on what is doing in Asia and the tropics. There can be no proper study of meteorology except as one includes the whole globe in his thoughts.

The past thirty years has seen the establishment, in every civilized country, of Weather Bureaus and Storm Warnings, but each has only a local jurisdiction, and even our national Signal Office, covering as it does the largest region of any, has recognized that our storms and weather are affected by atmospheric conditions far beyond our borders. In 1871, it began to collect ocean data, and since 1875, has compiled a daily weather map of the whole northern hemisphere. There has just come to hand a most extensive work by Buchan, published as one of the scientific results of the voyage of the "Challenger"¹ which shows month by month the condition of the atmosphere over the whole northern hemisphere.

But statistical and climatic averages are not dynamic meteorology and it is this latter field that the general problems of pressure and motion of the atmosphere press hard for solution. The past decade has seen important memoirs on fundamental questions from the hands of our ablest mathematical physicists ; those of Helmholtz and William Thomson on vortex motions and stationary waves ; of Oberbeck on the general circulation of the air and on cyclonic motions ; of Hertz, on adiabatic motions and of Bezold on non-adiabatic motions ; of Buchan, Hann and Rayleigh on diurnal bar-

¹ "Report on the Scientific Results of the Voyage of H. M. S. Challenger during the years 1873-76, Physics and Chemistry, Vol. II, part 5; Report on Atmospheric Circulation, by Alexander Buchan. London, 1889, 347 pages, 3 plates, 52 maps."

ometric fluctuations; of E. Poincaré on lunar tides in the atmosphere.

Hitherto, the professional meteorologist has too frequently been only an observer, a statistician, an empiricist—rather than a mechanician, mathematician and physicist. He has studied the atmosphere out of doors, without having had a preliminary training in the laws of fluid motion, so that much that has been written on dynamic meteorology has proved unsatisfactory. In fact there are now but very few laboratories in the world where the instruction can be given, and thirty years ago, there were none; but the recent advent of our foremost physicists into the field of investigation and the erection of laboratories for all manner of mechanical work, raise our hopes to the highest pitch.

The problems of meteorology are important enough and difficult enough to excite the ambition of the ablest of men; by their help, we shall yet make great progress in the prediction, not only of daily weather, but of extensive climatic changes, droughts and floods, months in advance; eventually we shall be able to state what climates must have obtained in past geological ages.

IX. *Instruction.*—Here I close this rapid sketch of the various divisions of terrestrial physics. Our German brethren have coined for it, the more proper title "*géo-physik*," and have already given us some extensive treatises covering the ground that I have indicated. We have thus a distinct branch of *geo-physical* study that has too rarely been recognized as yet either in our universities or our observatories. A few general remarks, or a chapter in some treatise on geology or physical geography or *météorology*, and thus the subject is dismissed and forgotten in the midst of the numerous other studies. Why is this so? We are told that there is no demand for instruction in these matters and no demand for such experts either in the business world or the scientific world; but surely, there is here some mistake. Our great national Bureaus, the Coast Survey, the Hydrographic Office, the Geological Survey and the Signal Office need the best of talent in these very branches of study. Most of our universities offer instruction in correlated matters; will they remain content to supply the demand for geometers, geologists, geodesists and geographers, and not supply geophysicists? Will the world's patrons of science maintain seventy-five American and two hundred and fifty foreign astronomical observatories, two hundred chemical laboratories and one hundred laboratories for molecular physics and omit to found one single one expressly for

terrestrial physics? Must our graduates of colleges be obliged to restrict their choice of professional studies to law, medicine, mining, navigation, civil and mechanical engineering, agriculture, electricity and chemistry, and not be invited to take up such studies as will fit them for the highest usefulness in geodesy, meteorology, oceanology and other practical studies?

You whose needs are already provided for, as to your special professions, let me beg of you to lend a helping hand to the broader physical science that stands awaiting recognition, and do what you can to encourage the study of the physics of the globe, a study which is now as a young plant whose strong healthy roots have taken hold of the soil and even penetrate to the geological rocks below; its growth is favored by the sunshine and the rains of heaven, the winds rustle its leaves; it is struggling for life and existence; give it shelter and nourishment that it may grow and drop its flowers and fruit into the laps of its benefactors. Don't poke it away in the corner of a building devoted to other objects, where it will die of thirst and starvation, but give it *the free air and its own homestead lot* and it will become as beautiful as the Cedars of Lebanon.

X. *To our patrons.*—In the preceding, I have sketched some hypotheses that seem to me most plausible in the present state of our knowledge, thus indicating the lines of work for students in the immediate future; these hypotheses may be bold and hazardous; they may fail and fall; then let better ones rise and bring us nearer the truth. But who will devote himself to these problems? Who will sacrifice a life time to tasks that only succeeding generations can fully profit by? Sometimes a man will single-handed take up some isolated question, or a government bureau may spasmodically devote a fraction of its energies to some one of these questions; our Coast Survey may do something in regard to the figure, the size and the attraction of the earth; it may even contribute to the elucidation of tides, of currents and of terrestrial magnetism; the Geological Survey may find it within its powers to lightly touch upon the questions of internal heat, plasticity, earthquakes, mountain building and the evolution of continents and oceans; the Astronomical or Naval Observatory may study changes of latitude; the Signal Office may see its way clear to study the atmospheric problems larger than American weather. Indeed a proper interpretation of the intent of the law warrants any Bureau Officer at Washington in spending time and money on investi-

tigations that are prospectively essential to the improvement of the business of his office ; or if he doubts this, he has only to properly present his needs, and the appropriation is usually made ; for the advancement of science is generally highly appreciated by members of Congress, whenever it promises a harvest of practical results for the benefit of the country..

In a republican, democratic government "of the people, for the people and by the people," the official study of scientific problems that are evidently of public importance can never be a matter of doubtful propriety ; the nation and the individual alike vie in labors for the public good ; the cosmic problems that I have enumerated need the coöperation of government officials and university educators and I hopefully look for some patron of science who shall set able men to work in an institution devoted to geophysics.

Who will domicile this important study among us? Who will repay to the earth what he owes to her by encouraging the scientific exploration of the origin of the gas and oil, the coal and iron, the silver and copper, the gold and diamonds that are so lavishly given forth by her whenever man seeks for them in the right spot.

Does it never occur to any one that the foundation of a special school for the thorough study of meteorology and methods of weather prediction would undoubtedly contribute greatly to the improvement of local weather predictions?

Does not the aurora by night and the needle by day perpetually tempt some one to contribute his all to the solution of these mysterious magnetic influences? At sea on cloudy nights and foggy days this little needle alone has stood between him and shipwreck.

Why found new colleges and universities to teach what is already taught elsewhere? *Exploration is the order of the day.* Give us first the means to increase knowledge, to explore nature and to bring out new truths. Let us perfect knowledge before we diffuse it among mankind, so that what we teach may with every coming year be nearer and nearer the eternal truth of God's creation.

Finally, and again, I present to you, OUR GLOBE,—THE HOME OF MAN. Love it as you would your own personal home. Search for its beauties as you would search for the sweet nooks in your own garden. God made it and gave it to us ; yea, He gave us to it ; and if He has given us the promise of a better land, yet He would not have us despise this. He has beautified it. He saw that it was good. Let us by our appreciation of His work show that we are in sympathy with Him.

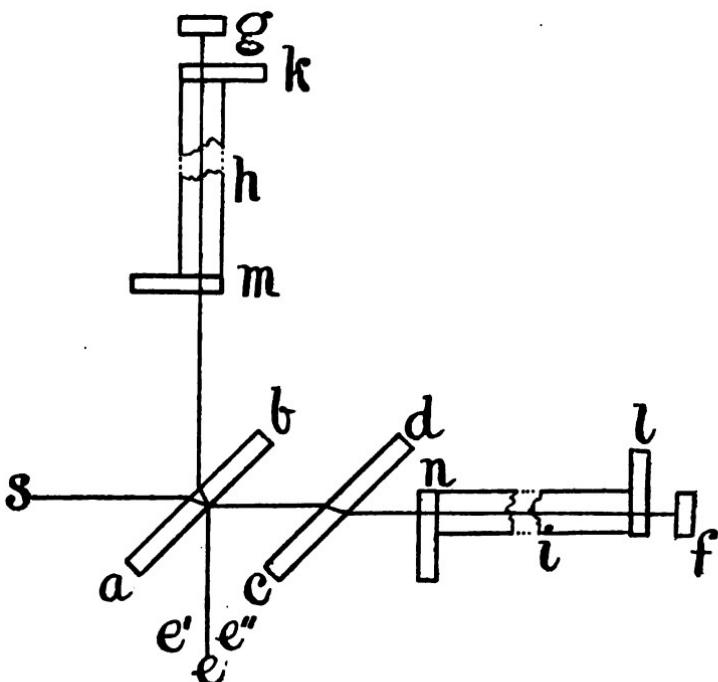


PAPERS READ.

ON THE VELOCITY OF LIGHT IN A MAGNETIC FIELD: A REPORT OF EXPERIMENTS MADE WITH THE AID OF A GRANT FROM THE RESEARCH FUND OF THE ASSOCIATION. By Prof. EDWARD W. MORLEY, Cleveland, Ohio, AND Prof. HENRY T. EDDY, Cincinnati, Ohio.

* PART I. DESCRIPTION OF APPARATUS. BY EDWARD W. MORLEY.

1. The optical part of the apparatus consists of the interferential refractometer used by Michelson in his experiments to determine whether



Light moves with the same velocity in different directions in the solar system. A train of waves from a source, *s*, is divided at the second surface

of ab , which is coated with silver of such thickness that the division is nearly equal. If now the mirrors, f and g , are properly adjusted the two parts re-unite at ab , and interference bands can be seen by the eye at e if the distances of f and g from ab are properly related. If now, any force acts intermittently to change the velocity of one part of the ray while their paths are separated, it may be detected by a motion of the interference bands if not too small.

2. If now we put two tubes, h and i , in the paths of the divided ray, making these of nearly the same length and closing them with plane parallel glasses of equal thickness, and fill the tubes with carbon bisulphide, we shall still obtain interference fringes. If we surround each with a coil, use polarized light, and close the circuit through one coil, there will be a rotation of the plane of polarization in the magnetic field. Now, if the rotation be not so great as to prevent, or too much affect, the interference of the parts of the divided train of waves, a change of the velocity of light in the magnetic field will produce a displacement of the interference bands. If we complete the circuit in the two coils alternately, we double the displacement which it is sought to detect.

3. If any displacement be observed, it will be necessary to determine whether it be due to strain or displacement of parts of the apparatus. In the case of the plates ab , cd , f and g , this may be accomplished by watching the effect of closing alternately the circuits through the two coils while the tubes contain only air. But a disturbance which should affect the position or length of one of the tubes, h and i , needs special means for detecting it. The plates, therefore, which close the ends of these tubes are placed as shown at k , l , m and n , and are silvered except where they cover the tube. When proper adjustments are made, the observer can see interferences through the tube by placing the eye at e , interferences at the covers of the nearer end of the tube by placing the eye at e' , and interferences at the covers of the farther ends of the tubes by placing the eye at e'' . Since the interferences in the second and third cases are produced by rays which pass only through air and glass, the interference bands can be so adjusted as to detect with ease a displacement which would be entirely insensible in the irregular and unstable interference bands produced after light has passed through a liquid so optically unstable as carbon bisulphide. Our means of detecting the effect of mechanical disturbance were therefore greatly superior to those of detecting the change of velocity in question, and the statement that no disturbance of interference bands was caused by mechanical disturbance is open to no doubt.

4. The plates ab and cd were 9.8 cm. by 2.0 cm.: g and f were 2.0 cm. by 2.0 cm. k , l , m and n were 4.3 cm. by 2.0 cm. The tubes, h and i , were 1.7 cm. in inside diameter, and were 38.1 cm. long. They lay in adjustable supports, and were not in contact with the coils which surrounded them. Around a rectangular space 4.2 cm. by 2.2 cm. was first a non-conducting layer .6 cm. thick, then a space .6 cm. thick for the circulation of water; and lastly, a coil made of wire .38 cm. thick. Each coil was

made of two wires laid side by side, so that when a current was passed through both wires in opposite directions, its effect was null. A commutator was arranged so that a constant current was passed through one wire of each coil, while the current through the second wire was made to neutralize or double the effect of that in the first. The heating by the current was therefore identical in both coils. The wire of each coil weighed about 82 kilogrammes, and the length covered by the wire was 30 cm. in each coil.

5. The flame of a Bunsen lamp colored by sodium was commonly used, because the interference bands can then more easily be given forms which permit delicate discrimination; a luminous gas flame and the electric arc were also employed. A Nicol prism was sometimes interposed, and the plane of polarization was put in various positions. The optical parts of the apparatus were so adjusted that the interference bands apparently coincide with the more distant mirror: their displacement can then be detected by reference to lines ruled on one of these mirrors.

PART II. CHANGE OF DENSITY OF CARBON BISULPHIDE IN A MAGNETIC FIELD. BY EDWARD W. MORLEY.

In the examination of the effect of a magnetic field on a ray passing through it, the appearance on making and breaking the circuit suggested the probability of a change in the density of carbon bisulphide while in the magnetic field. There was produced an instantaneous displacement of the interference of bands which was several times as large as the permanent effect. It was easy to imagine that the force bringing the molecules into the new positions in which they produce rotation in a ray of light might carry them beyond the position of equilibrium, to which they quickly returned. To examine this phenomenon, a thick brass box filled with carbon bisulphide was placed in each coil, the two boxes were connected with each other and with a glass tube of small diameter. After all parts of the apparatus had come to a uniform temperature, the level of the carbon bisulphide was brought to a convenient point in the glass tube, and a current of 27 amperes was sent through the coils for two seconds, four times at short intervals. There was a measurable rise of the liquid at each, making circuit of about .06 mm., instantly falling to .03 mm. On breaking circuit, there was an instantaneous fall to —.03 mm. and instantly a rise to .00 mm. This could be well measured three or four times by means of the eye-piece micrometer of a cathetometer having an amplification of about 60 diameters, the probable error of a reading being less than .006 mm. But after three or four measurements, the heat developed in the coils made it necessary to wait many hours for a constant temperature. There were 380 cc. of carbon bisulphide in the magnetic field; the area of the capillary tube was .55 square millimetre; the permanent decrease of density, therefore, was one part in 28,000,000. The intensity of the field was 1650 centimetre-gramme-second units.

MAGNETIC AND GRAVITY OBSERVATIONS ON THE WEST COAST OF AFRICA
AND AT SOME ISLANDS IN THE NORTH AND SOUTH ATLANTIC. By E.
D. PRESTON, U. S. Coast and Geodetic Survey, Washington, D. C.
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[ABSTRACT.]

THE value of certain magnetic observations depends on the interval of time between the determinations: gravity observations, when their object is a more accurate knowledge of the shape of the earth, depend for their value on the area over which the stations are scattered. Coast, continental and island stations, as well as those on mountains and plains, each have their own particular evidence to furnish. It must be admitted that this evidence is not always unanimous, but the lack of unanimity may result from a real cause inherent in the nature of matter, or it may be only apparent and come from the difference in instruments and in the interpretation of results. Then again if it may be assumed that the mean figure of the earth is already known as closely as the pendulum will give it research should be carried on by determining local variations of the force of gravity.

It is evident that extended voyages offer exceptional facilities for increasing our knowledge in magnetism and gravitation, and should be utilized when possible. Such an occasion presented itself in the fall of 1889, when it was proposed to send an expedition to Africa to observe the total eclipse of the sun on December 22. The eclipse party was under the direction of Prof. J. P. Todd of Amherst College. Through his courtesy, and by authority of Commodore Dewey, Chief of Equipment and Recruiting U. S. N., the superintendent of the Coast and Geodetic Survey, sent one of the assistants to make magnetic and gravity observations. Originally, work of this nature was only proposed for the Eclipse station in Angola. It was noticed, however, that on the return trip several important stations might be visited without much loss of time, and that these stations had already been occupied by earlier pendulum observers. Permission was therefore granted by the Honorable Secretary of the Navy, for the vessel to stop at the Cape of Good Hope, St. Helena and Ascension long enough to enable the Coast and Geodetic Survey representative to make his determinations. In addition to this, stops were made at Barbadoes and Bermuda, and through the kindness of Captain Yates, commanding the Pensacola, full series of observations were obtained. On the outward trip time was more valuable since it was desirable to reach Angola as soon as possible. For this reason only magnetic work was attempted at the coaling places. There appear then as the result of the trip fourteen magnetic and eight gravity stations, distributed as follows:—Azores, Cape Verde Islands, Freetown in Sierra Leone, Elmina on the Gold coast, St. Paul de Loanda, and Cabiri in Angola, Capetown, St. Helena, Ascension, Barbadoes and Bermuda. On both St. Helena and Ascension the force

of gravity was measured at the level of the sea and at the highest elevation practicable. On the former island, Jamestown was selected for the lower point and Napoleon's residence at Longwood for the upper. The pendulum apparatus was set up in the kitchen of what is known as Napoleon's new house, now leased by Mr. Deason. At Ascension the sea station was at Georgetown, the other was on Green Mountain. Foster's observations at the latter place show a defect of gravity of two oscillations per day as compared with the sea-level. That is to say, that having corrected his oscillations on the summit, for elevation, and for the effect of the mountain, on the supposition that it was solid, he found the result to be less than the number of oscillations actually counted at the sea level. As some recent observations on island mountains give results at variance with this, it was desirable to repeat the Ascension work with modern instruments. Indeed it was to connect with Foster and to verify his result for Ascension, that an extension of our gravity work was proposed. The entire voyage lasted eight months, of which one hundred and twenty-three days were spent on ship board. The area covered by the stations extends from Washington, on the north and west, to Cape Town on the south and east, making a range of 78° in latitude and 96° in longitude. It so happens that the most northern station is also the most western and the most southern station the most eastern. The elevations range from seven feet at Bermuda to 2250 at Ascension. The magnetic observations at the Azores, Cape Verde Islands, Freetown and Elmina were shortened by lack of time, one or at most two days being devoted to each place; but at all other stations the declination, dip and horizontal force were determined on each of three consecutive days, besides, at a few stations, making hourly observations on several other days. At Cabiri, the needle remained suspended during the total eclipse but no abnormal change was noticed. For the gravity work at every station about thirty swings were made with each pendulum, using them in both positions and continuing the observations through the entire twenty-four hours. The pendulums used were Nos. 2 and 3 of the Peirce pattern, being of the invariable reversible type. The length of the former between the knives is one metre; that of the latter a yard. No. 3, besides having been employed at numerous home stations, has now been swung at thirteen foreign ones including several in the Pacific.

Of the fourteen magnetic stations all but one have been occupied by earlier observers. Determinations were made in the Azores between 1497 and 1829. In the Cape Verde Islands between 1841 and 1853. In Sierra Leone between 1826 and 1842. At Freetown by Sabine in 1822. At Cape Coast Castle seven miles from Elmina in 1838 and 1841. St. Paul de Loanda has a magnetic observatory and issues published reports containing results for declination, dip and intensity. The work at the Cape of Good Hope between 1840 and 1850 is well known, and Sabine's account of five years' observations at St. Helena from 1841 to 1845 is one of our classic magnetic volumes. The station at Sisters' Walk in Jamestown was

selected by Sir James Ross in 1840, but as the values at this point are not normal, the Coast Survey station was chosen some distance back from the mountain and midway between it and Ladder hill. Sisters' Walk is close against the foot cliffs of Rupert's hill.

The dip was measured at Ascension in 1822 and all three elements were determined by the Challenger Expedition, in 1876. Observations have been made eight times at the Barbadoes between 1726 and 1844, and six times at Bermuda between 1831 and 1876. The Coast Survey determinations at the latter place were made on Nonsuch Island at the extreme eastern end of the group. They are, undoubtedly, the only magnetic observations ever made at this place and it is more than probable that the station will never be occupied again. This is to be regretted, but it was necessary to utilize the ten days spent in quarantine in order to make steamer connection. The work had to be done here if it was to be done at all in Bermuda.

The gravity stations in common with other observers were Cape Town, St. Helena and Ascension. Foster's celebrated series includes all of these. Sabine determined gravity at Ascension in 1822 and De Freychnet observed at the Cape in his voyage around the world in 1819. Besides the idea of verifying Foster's result that Ascension Island is too light, it was highly desirable to connect his series with our own which now includes island as well as continental stations. But it was assumed sufficient to have the series exactly coincident at two points; Lemon Valley was therefore not re-occupied at St. Helena. Moreover, the Ascension stations are practically identical in the two series and St. Helena was occupied at the sea as well as at the summit, which gives a third connection with Foster, and supplies a check on his Ascension results. In order that an approximate estimate might be made for the matter lying above the sea-level at St. Helena, many heights were determined barometrically by Professor Abbe, of the United States Signal Service. By using these, some idea of the attraction of the mountain may be had and it will be then seen whether the islands in the Atlantic and Pacific differ essentially as regards internal structure. Rock specimens were brought from both St. Helena and Ascension. Their densities may give an indication of what we should look for in the gravity results, providing that both islands were subject to the same laws of formation.

The Pensacola staid at St. Helena but sixteen days. During this time two stations were selected, the pendulums were swung through six consecutive days and nights at each place, magnetic observations were made on six different days and the instrumental outfit transported to and from the mountain top. Equally rapid progress was made at Ascension where the conditions were similar in many respects. This amount of work could not have been accomplished, however, without the able and generous assistance of the Naval Cadets attached to the Pensacola and of Professor Bigelow, of the eclipse party, to all of whom I wish here, to express my obligations. I wish also to tender thanks to Capt. A. R. Yates, commanding, and to Lieut. Commander Hanford, executive officer of the

Pensacola. The landing and shipping of the instruments was always a matter requiring care, and was often done under difficulty, yet in the numerous transfers nothing was ever broken or lost.

An account of the trip would be incomplete without a due acknowledgment of the services rendered by the government officials at the different stopping places. At Loanda, the governor of the province of Angola gave us free passes for all travel on the railroad from the coast to Cabiri, where the party went to observe the eclipse on Dec. 22nd. At the Cape of Good Hope every facility was given. Her Majesty's Astronomer, Dr. Gill, kindly furnished myself and aid with quarters at the observatory, and made a special time determination every night for the pendulum work. The railroad authorities offered complimentary tickets for a trip to the Diamond fields at Kimberly, six hundred miles into the interior. At St. Helena, Gov. Antrobus tendered the use of the public park for magnetic observations, and the library room of the police court for the gravity work. The unique character of the island government at Ascension placed us under more than ordinary obligations. As there are no civilians at this place we were necessarily the guests of the Admiralty. Captain R. H. Napier, R. N., placed at our service an entire building in Bunghole Square for the observations at the Garrison. The pier was built for the transit, tents were erected for magnetic and astronomical work, and guard duty performed by the marines. A ration per day from the island stores, was served to each member of the party during the stay, and all transportation to and from Green Mountain gratuitously given. At Barbadoes and Bermuda we were again on English soil and received the usual generous welcome. At the former place Gov. Sendall came to Hastings and made a personal examination of the instruments and methods of observing. At the latter, General Newdegate kindly gave us the use of the government launch for transportation besides showing other attentions of an unofficial character.

The definitive results, from the observations on this voyage, may be expected before the next meeting of the Association. Whether they show the Atlantic islands to be light or heavy, as compared with continental masses, they will at least add considerable new material for the determination of the earth's figure.

The following table contains a list of the stations with their approximate positions, date of occupation, kind of determination and initials of observers.

SECTION B.

NAME.	STATIONS.	APPROXIMATE POSITION.			KINDS OF DETERMINA-	EPOCH 1889.	OBSERVERS.
		φ	λ	h. ft.			
Washington, Coast Survey Office and Smithsonian.	+ 35° 53'	+ 77° 1'	34	Magnetic and Gravity.	Sept. and Oct.	P., F.	
Azores (Fayal).	+ 33 32	+ 28 39	30	Magnetic.	Nov.	P.	
Cape Verde Islands (Porto Grande).	+ 16 53	+ 24 69	15	Magnetic.	Nov.	P.	
Sierra Leone (Freetown).	+ 8 30	+ 13 14	10	Magnetic.	Nov.	P.	
Gold Coast (Elmina).	+ 5 5	+ 1 20	10	Magnetic.	Nov.	P.	
Angola, Louanda.	- 8 49	- 13 7	150	Magnetic and Gravity.	Dec.	P., M.	
Angola, Cabril.	- 8 47	- 13 59	200	Magnetic.	1890.	P.	
Cape Town, Royal Observatory.	- 33 56	- 18 29	37	Magnetic and Gravity.	Jan. and Feb.	P., Pa.	
St. Helena, Jamestown.	- 15 55	+ 5 43	33	Magnetic and Gravity.	Feb.	P., M., Mac., B.	
St. Helena, Longwood.	- 15 57	+ 5 40	1750	Magnetic and Gravity.	Mar.	P., M., Mac., B.	
Ascension, Georgetown.	- 7 58	+ 14 25	15	Magnetic and Gravity.	Mar.	P., M., W., B.	
Ascension, Green Mountain.	- 7 57	+ 14 22	2050	Magnetic and Gravity.	April.	P., M., W., B.	
Barbadoes, Bridgetown.	+ 13 7	+ 59 36	60	Magnetic and Gravity.	May.	P., M., W., Mac.	
Bermuda, Nonsuch Island.	+ 33 21	+ 64 39	35	Magnetic.	May.	P.	
Bermuda, St. Georges.	+ 32 33	+ 64 40	7	Gravity.	June.	P.	
Washington, Smithsonian.	+ 33 53	+ 77 1	34	Gravity.	July.	P., F.	

P. The author.
 F. S. Forney, U. S. Coast and Geodetic Survey.
 F. W. P. Williams, " " "
 M. G. R. Marvel, Naval Cadet, U. S. N.
 Pa. J. B. Patton, " " "
 Mac. W. D. MacDougal, Naval Cadet, U. S. N.
 W. P. Williams, " " "
 B. Professor Bigelow.

ON THE USE OF THE MAGNETOGRAPH AS A SEISMOSCOPE. By T. C. MENDENHALL, Director U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

MANY instances are on record in which self-registering magnetometers have shown the effect of seismic waves on the photographic trace of their movements, when the existence of such waves was not otherwise noted. It has generally been assumed that the disturbance of the delicately suspended magnet was purely mechanical and that it was, therefore, in principle the same as that of any ordinary seismoscope. Evidence exists, however, to show that it may often be attributed to a real change in the magnetic field which is simultaneous with the seismic phenomenon. It was suggested that this change in the magnetic field is due to the sudden and great stress to which the earth or a part of its crust is subjected on the occurrence of an earthquake. The well established lunar variation of the magnetic declination and especially as exhibited in the investigations of the Los Angeles series of magnetic observations by Assistant C. A. Schött, U. S. Coast and Geodetic Survey, were graphically shown and the evidence in favor of this disturbance being due to a stress wave and therefore a real tidal effect, was considered. If the theory offered be sustained by a more complete examination of the facts, it will show that the magnetograph may be used as a seismoscope with the peculiar advantage that it may record earthquakes which occur at a distant point and which cannot be detected by ordinary mechanical methods.

NEW METRIC STANDARDS. By T. C. MENDENHALL, Director U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

EXHIBITION of models with statement of equations of the metre and kilogramme.

EXHIBITING SEISMOSCOPES. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

THE Gray-Milne seismograph here exhibited is designed to record the intensity of earthquake motion by automatically drawing a diagram of three components on a moving band of paper. Alongside the record of motion a record of time is made mechanically by means of a clock. In this way the direction of the motion, the time of occurrence of the shock and the intensity of the forces which have to be resisted by structures can be obtained. Automatic mechanism is provided for increasing the rate of motion of the paper band at the beginning of the earthquake and changing it back to slow after the earthquake. The machine is thus capable of recording any number of successive earthquake disturbances.

THE EFFECTS OF THE ATMOSPHERE AND OCEANS ON THE SECULAR COOLING OF THE EARTH. By R. S. WOODWARD, U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

THE object of this paper is to call attention to the relatively unimportant part played by the atmosphere and oceans in the secular cooling of the earth. It is shown by analysis that the law of cooling is expressed by a principal term *plus* terms of a low or minute order dependent on the atmosphere and oceans. The conclusions reached are:—

1. That secular cooling goes on substantially as it would if the earth were devoid of atmosphere and oceans.
 2. That the mere difference in capacity of the atmosphere and oceans to transport heat can produce no sensible effect on the distribution of the isogeotherms.
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DESCRIPTION OF THE EQUAL TEMPERATURE ROOM IN THE SHANNON OBSERVATORY AND PHYSICAL LABORATORY OF COLBY UNIVERSITY. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

OBJECT sought in the construction: the production of a given temperature and the maintenance of that particular temperature until the complete thermal effects of this condition have been secured.

It consists of an interior room on the ground floor of the building, 58 feet in length, 30 feet in width and 16 feet in height. The inner walls are of brick one foot in thickness. The room is surrounded on the four sides by an air space two feet in width. Above the ceiling there is an air space three feet in height. There is a cellar with cement bottom of the dimensions of the main building. The outside walls are of brick and have a thickness of 20 inches with an air space of two inches. An elevation of temperature is produced primarily by an overhead system of steam circulation. The temperature is controlled by a supply of either hot or cold air delivered from a Sturtevant blower driven by a 12-horse-power engine. Hot or cold air can be delivered in any quantities required.

- (a) Into the cellar.
- (b) Into the space between the walls on either of the four sides separately or into all at the same time.
- (c) Into the space between the floors.

It has been found by experience that for temperatures between 45° and 90°, a constant temperature can be maintained for an indefinite length of time within 0.1° Fahr.

IS THERMOMETRY AN EXACT SCIENCE? By Prof. WILLIAM A. ROGERS,
Waterville, Me.

[ABSTRACT.]

An account of the investigation of the errors of a standard thermometer by the Thermometric Bureau of the Yale Observatory by the U. S. Signal Office and by the writer. Consideration of the causes of the variations in the different results obtained. (a) The true basis of the two zero points. (b) The determination of the intervening points. (c) The deviation of the middle point determined by calibration from the results given by the air and the hydrogen thermometer for different kinds of glass. (d) The necessity of publishing separately the calibration and the corrections as shown by the air thermometer.

Consideration of the classes of errors to which thermometers are liable under the following conditions: (a) In the measurement of air temperatures for both vertical and horizontal positions. (b) In the measurement of the temperatures of liquids. (c) In the measurement of the temperature of metals.

In comparison of different thermometers under either of these conditions, the observations can be so arranged that about equally trustworthy results will be obtained.

Consideration of the causes which affect the varying relations between different thermometers at the same temperature. Of these may be mentioned:

- (a) The previous thermal condition of the thermometers compared.
- (b) The effect of evaporation.
- (c) The interradiation of heat between the thermometers and the metal upon which they rest, either by actual contact of the bulb or under varying distances of the bulb from the metal. This includes the investigation of the extent to which a large mass of metal controls the indication given when the bulb is in contact with the metal.
- (d) The effect of local variations of temperature in the surrounding air upon bulbs of different shape and size.
- (e) The effect of a slow change in the temperature of the glass stem relatively to the more rapid change in the mercurial column.
- (f) Experimental determination of the extent to which water controls the temperature of a metal under the following conditions: (1) With the bar submerged deeply in water. (2) With the bar having one surface kept below the surface of the water. (c) With the bar partially submerged.

DETERMINATION OF THE TENSION OF THE VAPOR OF MERCURY AT ORDINARY TEMPERATURES. By EDWARD W. MORLEY, 749 Republic Street, Cleveland, Ohio.

[ABSTRACT.]

FIVE years ago the tension and weight of the vapor of mercury at ordinary temperatures had not been satisfactorily determined. Regnault assumed the tensions to be .08 mm. at 0° C. Hagen's determination was

affected with some error. Hertz could detect no tension measurable by his process below 60° C. Thorpe determined colorimetrically the mercury in a globe in which a jar of mercury had been suspended; the value obtained was much too large. Carnelly's determinations were all at high temperatures.

I have now determined the weight of the vapor at ordinary temperatures directly by one series of experiments, and the tension directly by a second series. In the first series, an inert gas was passed through a quantity of mercury so as to carry away a measured volume of vapor assumed to be saturated. The mean temperature was known from a recording thermometer, the volume of gas was measured by a gas meter and the weight of the mercury vapor was found from the loss of weight of the mercury. Continuing each experiment some fifteen days, the tension of the vapor at about 16° C. was found to be twelve, thirteen, sixteen, and fourteen ten-millionths of an atmosphere.

To explain the principle of the other experiment, imagine a small receiver containing air saturated with moisture suddenly put in communication with an enormous receiver containing only the saturated vapor of water. The pressure in the small receiver would fall at a rate depending on the nature of the communication and the difference of pressure until the pressure in the two should be the same; and, after this, air would pass out of the small receiver by diffusion. If the small receiver be a McLeod gauge using water instead of mercury, a series of measurements of the tension of the air remaining in the small receiver may be imagined, which should show the tension of the air at the time when the law of decrease of tension should change, from which the tension of the vapor of water could be inferred. Four experiments were made with a McLeod gauge connected to a Geissler pump by a tube two metres long. The tension of the air remaining when the law of decrease of tension suffered a somewhat sudden change could be identified tolerably well. One experiment made before I had any intimation whatever of the quantity to be expected gave twelve ten-millionths of an atmosphere; three experiments made after those by the first method had been completed gave thirteen, thirteen, thirteen ten-millionths. Since this work was begun, Van der Plaats has made numerous measurements by passing a measured volume of air through mercury, and determining the mercury contained in the air by the use of absorption reagents. His result is very different from mine, so that the matter requires further investigation.

RADIATION AT THE RED HEAT (PRELIMINARY NOTE ON THE RADIATION FROM ZINC OXIDE). By Dr. EDWARD L. NICHOLS, and BENJAMIN W. SNOW, of Cornell University, Ithaca, N. Y.

[ABSTRACT.]

THE term "red heat" is here used to designate those temperatures lying between the point at which radiation first begins to make itself visible to the eye and 1000°.

The object of the investigation, of which this communication is merely a report of progress, is the study of the radiation from various surfaces, especially from such as might, from their nature, be expected to follow laws of change of radiating power, with varying temperature, other than those which are followed by platinum and carbon.

The oxide of zinc is a substance which possesses the peculiarity in question to a very marked degree. The authors have, accordingly, selected it as a material upon which to perform the preliminary experiments to be described in this note. In these experiments, the relative intensities of radiation in the visible spectrum of a strip of glowing platinum at various temperatures within the limits already indicated were carefully measured by means of a polarizing spectro-photometer. The temperatures in question were calculated by Matthiessen's well-known formula,

$$I = I_0 (1 + 0.00000861 t + 0.0000000085 t^2)$$

from measurements of the elongation of the foil.

The face of the foil was then coated with a film of the oxide of zinc, by smoking the platinum in a flame of the burning metal. The platinum strip with its coating of oxide was heated by means of the electric current until it emitted light of sufficient intensity for measurement.

At temperatures below 700 degrees centigrade, the spectrum of zinc oxide was found to be everywhere weaker than that of platinum at the corresponding temperature, the distribution of intensities being such as one might expect from Kirchhoff's law of radiation and reflection. At a temperature a very little above 700 degrees, however, the character of the radiation from zinc oxide was found to undergo certain remarkable changes. Its spectrum became everywhere brighter than the corresponding spectrum of platinum, the ratio rising steadily from about one or two at wave length $\lambda = 6400$ to a maximum value of about five or six in the region $\lambda = 4850-4500$, in the case of a freshly coated film. This condition was found to be an evanescent one, the maximum in the case of films which had been subjected to these temperatures for a short time falling to about three in the above region, the general form of the curve, however, being little changed.

As the temperature rises, the radiation in this region becomes extremely fugitive, and the difficulties of obtaining quantitative determinations were very great. At the end of ten seconds, for instance, the radiation at $\lambda = 4850-4500$ was about thirty times that of platinum for the same region and temperature. At the end of one minute, it had fallen off to fourteen times, and at ten minutes to six times. The detailed study of this region of the spectrum for the purpose of noting the existence of sharply defined bright bands has not yet been carried out. It is probably not without significance, however, that the region in question contains within its limits the three bright lines of the spectrum of zinc-vapor at $\lambda = 4814, 4758$ and 4714 .

The evanescent character of the radiation from zinc oxide seems to point to the fact that we have to deal with a case of phosphorescence by heat, which occurs at a much higher temperature than those which have already

been described; or, at any rate, that the phenomenon comes under the broader term luminescence, as defined by Wiedemann. The authors suspect that the phenomena included in this preliminary investigation are not confined to zinc oxide, and it is their purpose in the near future to extend their measurements to other substances, in particular to the oxides of other metals.

REPORT OF OBSERVATIONS MADE IN FOUR BALLOON ASCENTS. By W. H. HAMMON, Signal office, St. Louis, Mo.

[ABSTRACT.]

In the spring of 1885 a series of four balloon ascents were made for the purpose of taking meteorological observations. They were made under the direction of Prof. Cleveland Abbe, of the U. S. Signal Service, Prof. S. A. King acting as aeronaut and W. H. Hammon as observer. The ascensions in every instance took place from the grounds of Girard College, Philadelphia, Pa., in a balloon called "The Eagle Eyrie;" the capacity of which was about 25,000 cubic feet.

The observations were, principally, for the purpose of studying the variations in temperature and moisture, with elevation, and noting the velocities and directions of the higher air currents. These latter were determined by noting on a map, at frequent intervals, the position the balloon occupied above the earth. The thermometric observations consisted of wet and dry-bulb readings, made with the whirled psychrometer, after the manner used by DeSasure and Hazen. It is believed that, with the exception of observations since made by Professor Hazen, these are the only balloon observations ever made in this manner. From careful experiments, it was determined that the thermometers used were sufficiently sensitive to return to within $0^{\circ}.5$ of the temperature of the air, from a temperature 5° above or below that point, in one minute and seventeen seconds. The air pressures were determined from readings of an aneroid barometer, made by Jas. W. Queen & Co. Immediately after each voyage, this instrument was placed under the receiver of an air pump with a mercurial barometer, and the pressure reduced gradually to the lowest point observed in the ascent, and comparisons made from which corrections were determined for the scale readings. The instruments were read in the following order: time, barometer, psychrometer, whirled and read, barometer again, time again. With the exception of the first ascent, not more than two and a half minutes were consumed in the series.

Ascensions were made on Jan. 19, Mar. 18, Mar. 27 and Apr. 16, 1885. During the first ascent, an area of high barometer extended over the eastern half of the United States accompanied by cold weather and northwest wind. The northwest current was but 8000 feet in thickness, while passing through it, the temperature fell from $18^{\circ}.6$ F. to $8^{\circ}.7$ F. but it rose 4° while rising 1,800 feet in the southwest current above. The rela-

tive humidity diminished from 87.7 per cent on the ground at starting to 13.6 per cent at the highest altitude, *i. e.*, 4,800 feet.

The temperature was 20° lower on the morning of the day of the second ascent than on the day preceding. The sky was covered with stratus clouds, which were entered at an altitude of about 2,500 feet. The wind below the clouds at starting was northeast and above it was from the southeast. The lowest temperature, 15° , was observed at the lower edge of the cloud, while the highest observed was at the upper surface at which point it had risen to 25° . The temperature on the ground at starting was $24^{\circ}8$. The average thickness of the cloud was about 800 feet. During the 1,500 feet of the ascent above the cloud, there was a slight decrease in temperature. Attention is called to the fact that in both these ascents made during a cold-wave, the current of cold northwest wind was only about 3,000 feet in thickness.

The third ascent was made on a day when the sky was covered with high stratus clouds. During the entire ascent of 6,200 feet there was quite a uniform decrease in temperature, averaging one degree for every change in elevation of 550 feet. On this ascent the balloon travelled 70 miles in an hour and fifty minutes, while the wind on the ground blew not more than six miles an hour.

On the fourth ascent the wind on the ground was from 15 to 20 miles an hour, while at the highest altitudes there was but a very slight motion of the balloon. On this voyage currents of air were frequently observed, apparently moving upward while the balloon was nearly stationary.

The results of the observations are shown in the following tables:—

DIRECTION AND VELOCITY OF WIND AT DIFFERENT ELEVATIONS.

DATE.	ALTITUDE. FROM.	TO.	DIRECTION OF WIND.	VELOCITY IN MILES PER HOUR.
Jan. 19, 1885.	On ground.		N. W.	15
	100	3000	N. W.	13
	3000	4770	S. W.	23
Mar. 18, 1885.	On ground.		N. E.	15
	100	2000	N. E.	13
	2000	4350	S. E.	15
Mar. 27, 1885.	On ground.		S. W.	18
	100	3000	S. W.	23
	3000	6200	S. W.	40
	On ground.		S. E.	8
Apr. 16, 1885.	On ground.		N.	15
	1000	4800	N. W.	10

RATE OF CHANGE IN TEMPERATURE FOR EACH INCREASE IN ELEVATION OF 1000 FEET.

DATE.	ALTITUDE. FROM. TO.		RATE PER 1000 FEET.	DIRECTION OF WIND.	REMARKS.
Jan. 19, 1885.	100	3800	4.6	N. W.	Light haze.
	3800	4600	3.6	S. W.	" "
Mar. 18, 1885.	100	2400	4.1	N. E.	Below clouds.
	2400	3450	4.6	?	In cloud.
	3450	4350	4.1	S. E.	Cloudless to cloudy.
Mar. 27, 1885.	100	650	5.6	S. W.	High clouds.
	650	2800	0.4	S. W.	" "
	2800	4700	4.1	S. W.	" "
	4700	6200	3.8	S. W.	" "
Apr. 16, 1885.	100	1600	6.1	N. W.	Cloudless.
	1600	3100	5.8	N. W.	"
	3100	3900	2.8	N. W.	"
	3900	4300	1.1	N. W.	"

SURFACE INTEGRALS IN METEOROLOGY. By Prof. FRANCIS E. NIPHER,
Washington University, St. Louis, Mo.

[ABSTRACT.]

WITH a view of testing the value of monthly and annual rain-charts of the United States published as Professional Paper No. IX, the author has determined the total rainfall in cubic miles per day during the months of the year and for the year.

These results are obtained by measuring the areas between lines of equal rainfall by the planimeter, summing the values by well-known methods.

The sum of the rainfall for the various months should give the same result as for the year, as deduced from the annual chart.

The author wishes to call attention to the value of such surface integrals as being the method which will indicate any change in the temperature or rainfall of a continent in less time than observations reduced in any other manner. The total annual rainfall on a continent, in cubic miles, is a quantity which varies little from year to year.

THE SPECIFIC INDUCTIVE CAPACITY OF ELECTROLYTES. By EDWARD B. ROSA, Baltimore, Md.

[ABSTRACT.]

ELECTROLYTES such as water, alcohol and certain alcohol derivatives and other liquids have an apparent specific inductive capacity varying from 5 to 80 and in case of water amounting to 75. Maxwell's electro-magnetic theory of light requires that $K=n^2$, i. e., the specific inductive capacity should equal the square of the index of refraction for light. The question then arises: Is the value of K for these liquids only an *apparent* specific inductive capacity, or is it a *real* specific inductive capacity and their cases *exceptions* to the rule? The force exerted between two electrodes in an electrolytic cell was measured under circumstances varied as follows:

1. Varying the potentials;
2. Varying the distance between the electrodes;
3. Varying the conductivity by changing degree of purity;
4. Varying the temperature;
5. Varying the speed of alternation of the currents;

and the results seem to show that conducting liquids have a *real* specific inductive capacity, just as non-conductors. The apparent exception to Maxwell's rule is explained by the great difference in the *periods* of the forces acting in the case of the action of light 10^{-16} seconds and of electrical stresses in the experimental measurements of K ; and experiments were cited to show that in all probability if we could command electrical forces alternating 10^{-16} times per second the value of K would be perhaps 2 instead of 75, and hence equal to n^2 . The investigation is to be continued.

PREDICTION OF COLD-WAVES FROM SIGNAL SERVICE WEATHER MAPS. By T. RUSSELL, Signal Office, Washington, D. C.

[ABSTRACT.]

GREAT areas of twenty-degree temperature-fall, sometimes exceeding a million of square miles in extent, follow an area of low pressure of barometer or come before an area of high pressure. The extent of area of fall is dependent on extent and depth of area of low pressure and area of high pressure and the density or sparseness of the isothermal lines in the region of the high and low. The *ensemble* of a temperature-fall in a cold-wave has graphically the semblance of a cone. The temperature-fall lines are sections of the cone and are generally elliptical in shape.

Taking the unit of cold-wave as a fall of ten-degrees over an area of 100,000 square miles, the extents of all the cold-waves in ten years have

been computed. On the weather-maps twenty-four hours preceding the occurrence of cold-waves, the deficiency of pressure in areas of low pressure and the excess in highs have been measured, taking the unit of extent as one inch over an area of 100,000 square miles. From one hundred and twenty-seven special cases the constants of a formula have been derived by the method of least-squares which gives the numerical relation between the extent of high and low and density of isotherms, and the extent of cold-wave following it.

A method of finding the maximum fall of temperature in a cold-wave and the place of its occurrence has been devised, based on the weighted mean of the temperatures to the northwest of the center of low pressure. The extent of a prospective cold-wave and the maximum fall being computed, which is the altitude of a cone, the area of the twenty-degree fall can be taken from a table suitably prepared for the purpose. The ratios of the axes of the twenty-degree fall areas are known for various types of pressure. The position of long axis of fall area extends in the direction of openness of isobars of low pressure, or parallel to the isotherms on the weather-map of preceding day.

Card-board ellipses are prepared with different ratios of axes, and of different areas from the smallest to the largest size of cold-wave, and adapted to the scale of the map in use. An ellipse of the size corresponding to the area of twenty-degree fall taken from the table is placed on the map in proper position and a line drawn around it. The thirty-degree, forty-degree, etc., fall lines are drawn in with respect to this and the center which is the place of maximum fall.

Tables and maps are shown, probable errors are given, etc., and comparison of results made with those derived from the method in use at the present time in predicting cold-waves.

KINEMATIC METHODS OF DETERMINING THE ALTITUDE AND MOTIONS OF THE CLOUDS. By Prof. CLEVELAND ABBE, Washington, D. C.

[ABSTRACT.]

THE marine nephoscope is available not merely at sea but equally so on any moving vehicle and affords a method of determining the motions and altitude of the clouds, that is often peculiarly elegant and convenient. The formulæ given by Finemann are deduced and the special plant for a permanent observing station is described.

THE MARINE NEPHOSCOPE. By Prof. CLEVELAND ABBE, Washington, D. C.

[ABSTRACT.]

THE author gave a general description of marine nephoscopes, followed by a special account of the one now exhibited as devised by the author for use on the U. S. S. Pensacola, in the recent scientific expedition to West Africa. The general importance of cloud work at sea. The peculiar value of the nephoscope in locating a distant storm centre.

MAGNETIC AND ELECTRIC PHENOMENA VIEWED AS MANIFESTATIONS OF A STATE OF STRAIN. BY PROF. W. F. DURAND, Agricultural College, Mich.

[ABSTRACT.]

In this paper an account is given of an attempt to utilize this view of magnetic and electric phenomena in the class room as a working hypothesis for the development of the fundamental ideas relating to magnetism and electricity.

For electrical phenomena the following assumptions are made:

(1) A universally distributed medium, (the ether, capable in general of receiving a strain and thereby developing a stress.

(2) A modification of the properties of the ether within gross matter, thereby changing its properties in relation to this strain, the change being in the nature of a decrease of elasticity.

(3) The equality of the strain on either side of a surface of separation between two media.

Strain is a manifestation of force, and lines drawn always in the direction of the force at any point will map out space in the usual way by lines of force. The force varies continuously unless there be a sudden variation in the elasticity. This in general occurs at surfaces of separation.

Since our experiments usually occur in air, the apparent difference in the value of the force within and without a body is due to the difference between the elasticity of the ether in the air and in the given body. Experiment seems to show that this elasticity is sensibly the same for all permanent gases and for the free ether. The phenomena of the velocity of light bear on this point. For conductors the elasticity of the ether is 0. It follows that the surface of separation is a surface of complete discontinuity. There is therefore no force within a solid or closed hollow conductor. Its surface is therefore an equipotential surface and its volume an equipotential volume. Wherever there is a discontinuity of force, phenomena are found said usually to be due to a charge. On this view a charge is simply a name signifying the supposed cause of certain phenomena attendant on a discontinuity of force. Every line of force has two ends, of different aspects with relation to the force, naturally corresponding to + and - charges.

In the usual way it is shown that near the surface of a charged body, $F_n - F_n' = 4 \pi \sigma$, and hence

$$\sigma = \frac{F_n - F_n'}{4 \pi}$$

It is also shown that the term *specific inductive capacity*, defined as the ratio of the capacities of two condensers, is simply the inverse aspect of ethereal elasticity. Also the question of relative conductivity depends on the relative location of the elastic limit of the contained ether. Among other propositions simply treated on this basis, mention is made of those relating to the screening effects of a conductor for the space on one side against the effect of electricity on the other. Also the fundamental propositions leading up to electric images.

For magnetic phenomena the assumption is made of a state of strain in some way connected with rotational motion about the direction of the developed force as an axis. Thence follows the existence of a field of force mapped by lines of force in the usual way. The force undergoes variation, continuous or sudden, according to corresponding variation of the media, but there are in general no complete discontinuities. The lines of force are all closed curves, the magnetic bodies being strung upon them, with discontinuities at entrance and exit. The difference in aspect between entrance and exit corresponds to + and — or north and south polarity. From these assumptions the common formula $\mu = 1 + 4\pi x$ is directly deduced. Also the mutual relations between para-magnetic and dia-magnetic bodies are easily seen to follow from the supposition that for the former the force in the metal is greater than that in the air, while for the latter the reverse is the case.

ELECTRICAL OSCILLATIONS IN AIR. By Prof. JOHN TROWBRIDGE and W. C. SABINE, Harvard University, Cambridge, Mass.

[ABSTRACT.]

IN repeating the experiments of Feddersen and Lorenz on the electrical oscillations in the discharge of a Leyden jar it seemed that the nature of the dielectric must greatly influence the result.

At the instant the electrical oscillations occur the glass of the Leyden jar is subjected to a strain which is more or less periodic. It is not probable that the capacity of a condenser is the same for rapid charges and discharges as for slow ones; and the measurements of capacity by the ordinary slow methods form no criterion of the capacity of glass under electrical influences which last but three millionths of a second.

We therefore concluded to employ an air condenser instead of one of glass, in order to detect, if possible, the effect of the medium of the dielectric upon electrical oscillations.

The air condenser, composed of nineteen concentric cylinders with a total capacity of 5318., was discharged through a wire having a self induction coefficient, corrected for the periodicity of the discharge of 41090., an Ohmic resistance similarly corrected of 1.54×10^6 , and a capacity of 200, all being in C. G. S. units.

The light of the spark, received upon a concave mirror of long focus, was reflected from a rapidly rotating mirror, and brought to a focus upon a sensitive dry plate. The rapidity of rotation of the mirror, about 8000 revolutions per minute, during the second within which the discharge took place, was determined accurately by means of a drum and break circuit pendulum.

On afterwards measuring the resulting serrated negative, it appeared that the time of the successive oscillations was not a constant, but was itself, more or less regularly, periodic. The first half oscillation was long;

the first double oscillation was short, the two successive double oscillations longer, and the fourth short.

We have been unable, as yet, to find a sufficient explanation of this in any defect in the methods or apparatus employed, and can only account for it by the hypothesis that a certain amount of the energy of the electrical discharge is spent in overcoming the dielectric viscosity of the air, and in straining the air dielectric, and that this strain is not immediately released in unison with the electrical surges.

(See Proc. Am. Acad. Arts and Science, Vol. xxv (N. S. xvii), p. 109.)

"WILSON HALL" THE PHYSICAL LABORATORY OF BROWN UNIVERSITY. By Prof. ELI W. BLAKE, Providence, R. I.

[ABSTRACT.]

By the will of the late George F. Wilson of Providence the sum of \$100,000 was bequeathed to the Corporation of Brown University "for a building devoted to scientific purposes." It was decided that this sum should be applied to the construction and equipment of a Physical Laboratory to be called "Wilson Hall," and a committee was appointed in June, 1887, by the Corporation of the University to obtain plans and superintend the erection of the building.

The plans submitted by Messrs. Gould and Angell of Providence were accepted by the Committee in November, 1888, and work was begun June 6, 1889. Owing to the unsettled state of the labor question unexpected delays were met with, and the building, although nearly completed, will not be ready for occupation before November next.

It is constructed in the most substantial and thorough manner with a view to extreme solidity and freedom from vibration.

In front and rear the building contains three stories, while in the central portion there are four. By this arrangement a number of smaller rooms are provided, for special researches—for storing apparatus—private rooms for the Professor and his assistants, etc., while the class rooms are ample and lofty.

The building is heated by direct radiation from steampipes, steam being supplied from an outside heating station so that there is no dust from coal or ashes to be feared. In that portion of the laboratory space devoted to magnetism, both steam and gas pipes are of brass.

In the lower laboratory stand two piers, one fourteen feet long by three feet wide, built up of solid masonry from the ground to the height of an ordinary working table,—the other ten feet long by four and a half feet wide and of the same height as the preceding. This pier not only serves as a good working pier, but also supports an arch of solid masonry surmounted by a levelled slab of stone eleven feet long by three feet wide which comes flush with the floor of the laboratory room above. Upon this slab the working table may be placed—or it may be removed at will, leaving the

entire floor-space free. In the lecture-room the lecture desk is supported on a similar slab (12 ft. \times 3½ ft.) resting on a pier of masonry, and flush with the platform.

All the piers are kept entirely independent of the flooring.

Besides the piers, stone slabs supported on stone brackets built into the walls have been provided as working tables, since experience seems to show that their stability compares very favorably with that of the piers themselves. Similar slabs are provided outside of such windows as seemed likely to be available for the Heliosstat.

A ten H. P. Otto Gas Engine will furnish power for the mechanical and electrical work to be done, and it is proposed to give special attention to these branches of Physics. For the present a larger share of purely constructive work is planned for, than perhaps properly belongs to a physical laboratory in the higher sense, but a movement is on foot which promises ultimately to enable the University to create a special department of applied mechanics, in which case such work will be transferred to another building.

In addition to the apparatus already belonging to the University, liberal provision has been made for the purchase of new instruments and every effort is being made to secure the best possible working outfit.

After long years of impatient waiting Brown University is about to have a physical laboratory worthy of her reputation. We gratefully acknowledge our indebtedness to Mr. George F. Wilson, and trust that his benefaction may long be fruitful of good in the cause of science.

SPECIFIC HEAT OF BRINE USED WITH REFRIGERATING MACHINES. By Prof.
J. E. DENTON, Hoboken, N. J.

[ABSTRACT.]

IN measuring the refrigerating effect, in thermal units, of mechanical refrigerating machines, it is often necessary to use brine for receiving the cooling action of the refrigerating fluid. The quantity of brine cooled or circulated per unit of time, multiplied by its range of temperature and by its specific heat, measures the refrigerating effect. The brine which is thus used must generally be that made from common commercial salt, and is somewhat contaminated with iron rust after a short period of service. The paper shows that brine of this character has a specific heat agreeing at any given temperature with that of pure sodium chloride of equal specific gravity within about one per cent.

Also that the specific heat does not vary more than one per cent for a range of temperature from 60° to 0° Fahrenheit. As the minimum error of the mechanical measurements of the power of refrigerating machines and of the amount of brine circulated is from 5 to 10 per cent, specific heat values of pure sodium chloride as given in chemistry treatises

for 60° Fahr. may be used for calculations upon brine used in practical tests for any temperature between 60° and 0° Fahr. without introducing any important error.

METHOD OF MEASURING THE ELECTRICAL RESISTANCE OF LIQUIDS. By Prof. FRANCIS E. NIPHER, St. Louis, Mo.

[ABSTRACT.]

THE liquid with any desired electrode is placed in the arm of a Wheatstone bridge. Between the bridge and liquid is placed a commutator which is revolved by any method, at any speed which does not cause jumping of the brushes.

This prevents polarization at the electrodes. In case the resistance of a battery is to be determined, the measuring current does not affect the battery, and the battery current does not disturb the balance of the bridge.

The instrument is standardized by measuring any set of metal or carbon resistances first with the commutator at rest and then with the commutator in motion.

The resistance of the contact itself can be determined by methods well known.

During part of the revolution the resistance to be measured is cut out or short-circuited, as the brushes are in contact with both bars of the commutator. The relative duration for such short circuiting depends on the angle of the split in the commutator and the width of the brushes. It can be varied by using double brushes, with variable lead.

The best arrangement is one in which we have a double commutator mounted on a shaft, so arranged that the brushes of one commutator may be given any desired lead on the other, the two commutators being connected in multiple. The angle of lead is determined by means of a graduated circle and vernier.

AMPERE METRE FOR FEEBLE ALTERNATING CURRENTS; THE "FARADOMETER." By Dr. WELLINGTON ADAMS, St. Louis, Mo., read by Prof. FRANCIS E. NIPHER.

[ABSTRACT.]

THE paper points out the absence of, and need for, a commercial direct-reading, dead-beat ampere meter for the measurement of alternating currents of small volume. Calls attention to the fact that the Siemens Dynamometer is not adapted to this purpose, and that it is neither direct-reading, dead-beat, nor constructed with a view to commercial use. Details the

difficulties incident to the design of such an instrument. Describes in detail a new instrument of original design, which serves the purpose, and which has been christened the "Faradometer," more particularly because of its power to measure the feeble alternating currents generated by the faradic coils used for medical purposes, an accomplishment never before attained. Points out the special need for such an instrument in the medical profession, and shows its prospective usefulness and attainments in the field of electro-physiology, and electro-therapy, as also its value as viewed from a medical-legal standpoint.

NOTE ON CERTAIN PECULIARITIES IN THE BEHAVIOR OF A GALVANOMETER WHEN USED WITH A THERMOPILE. By ERNEST MERRITT, Ithaca, N. Y.

[ABSTRACT.]

The peculiarities observed occur under the following circumstances: A thermopile, one face of which is kept at a constant temperature, is connected permanently with a suitable galvanometer. On suddenly removing a screen so as to expose the other face to some source of heat, the needle of the galvanometer moves quickly to one side. In the course of a few seconds, however, it moves more slowly, stops, and moves backward a short distance. This behavior is then repeated, and it is only after a long series of such throws, which gradually become less and less marked, that the final steady deflection is reached.

It has been observed: (1) that the interval of time between two successive maxima or minima is constant, and equal to the period of free vibration of the needle; (2) that the first throw of the needle bears a constant ratio to the final steady deflection. This last fact was found to be true, within the error of observation throughout the range of the scale used. It follows that it is not necessary, in work with a thermopile, to wait for the needle to come to rest, but that the first throw, which occupies only a few seconds, may be used instead of the final deflection. Since the sensitive galvanometers that are used with thermopiles are especially liable to changes of zero point, and since at least four or five minutes are required for the needle to come to rest, this method of making readings leads to greater accuracy as well as to a saving of time.

The peculiar motion of the needle is found to be explained by theory if it is assumed that the heating of the pile takes place in accordance with Newton's law of cooling.

The equation representing the motion is found to be:

$$\theta = C e^{-kt} \cos(nt - \phi) + K - L e^{-kt}$$

in which θ is the deflection at any time t ; the other letters representing constants which depend on the dimensions of galvanometer and pile, the strength of the magnetic field, the resistance in the circuit, and various other constant quantities.

ON THE CORONA, A SOLAR AURORA. By PROF. FRANK H. BIGELOW, Washington, D. C.

[ABSTRACT.]

DEMONSTRATIONS were given of the following principal formulæ.

1. Equation of the lines of force of a polarized sphere

$$N = \frac{8\pi}{3} \cdot \frac{\sin^2 \theta}{r}.$$

the polar coördinates of points on a line of the order N , being r, θ .

2. Equation of the equipotential surfaces.

$$V = \frac{\cos \theta}{r^3}.$$

3. Gauss' Intercept Theorem.

$O T = 3. OS$. The $O T S$ are on the polar axis: O at the center of the sphere, T the intercept from the force-tangent, S the intercept from the circle-tangent.

An application of these formulæ to the stream lines of the solar corona shows that the observed lines are projected on the disk from the space positions referred to their places on the sphere. The angle through which a line would need to turn from the plane of the disk to the actual position, is found by the formula,

$$\sec^2 a = \frac{x_2^{\frac{2}{3}} y_1^{\frac{2}{3}} - y_2^{\frac{2}{3}} x_1^{\frac{2}{3}}}{x_1^{\frac{2}{3}} x_2^{\frac{2}{3}} - x_2^{\frac{2}{3}} x_1^{\frac{2}{3}}}, \quad \text{where}$$

$x_1 = r_1 \sin \theta_1$ and $y_1 = r_1 \cos \theta_1$, with subscripts for successive points on the lines, these coördinates being measured on the photograph of the disk.

The application of these equations to the measures made on negative No. 16, of the Corona of July 29, 1878, taken by Professor Hall, at La Junta, Col., shows that the coronal rays spring from a zone about ten degrees wide, the maximum being at 35° from the coronal pole; and the phenomenon is similar to that of an Aurora.

Formulæ were given for the computation of the position of the coronal north or south poles respectively, with the following results:

Coronal North Pole.

Heliographic Longitude, $66^\circ 56'.2$

" Latitude, $+ 85^\circ 44'.6$

Coronal South Pole.

Heliographic Longitude, $168^\circ 11'.1$

" Latitude, $- 80^\circ 39'.5$

It was shown that the ends of the coronal streamers are normally located directly over the sun spot belts, and it is inferred that the precipitation of the substances transported aloft by the coronal forces, in descending to the sun by gravitation produce the spots and the accompanying results.

Various conclusions that flow from these circumstances were briefly mentioned. The paper was accompanied by six diagrams and four tables showing the values derived from the computations, which are conclusive as to their meaning.

ON TERRESTRIAL MAGNETISM. By Prof. FRANK H. BIGELOW, Washington,
D. C.

[ABSTRACT.]

A DEMONSTRATION of the equations that were mentioned in Bulletin No. 18 of the U. S. Scientific Expedition to West Africa, is appended to that paper. A synopsis of a new theory to explain the causes of the periodic variations of the elements of terrestrial magnetism is given, enumerating the coördinates of reference, the poles of magnetism, and the formulæ for connecting all the quantities that are involved. The headings of the sections are as follows:

1. Terrestrial theories.
2. Fields of force in the æther.
3. The three poles (permanent pole, rotation pole and translation pole).
4. Axes of reference.
5. Two methods of discussion.
6. Composition of the fields.
7. The fundamental formulæ.
 - (1) For the rotation pole.
 - (2) For the translation pole.
8. The relative motion of the three poles.
9. Some practical comparisons between the theory and the observed phenomena.
 - (1) Long periods.
 - (2) Annual.
 - (3) Lunar.
 - (4) Diurnal.
 - (5) The distribution of the elongations.
 - (6) The latitudes.
 - (7) The opposite elongations of the north and south hemispheres.
 - (8) The disturbances.
 - (9) The aurora.

The present study goes only so far as to classify clearly the observations, and it is hoped that the proof may soon follow in the application of the theory to the recorded facts.

ON CERTAIN ELECTRIC PHENOMENA IN GEISSLER TUBES. By H. S. ROGERS
and Prof. THOS. FRENCH, JR., Cincinnati, O.

[ABSTRACT.]

THE ordinary illumination of a Geissler tube is effected by placing its terminal metallic electrodes in contact with the prime conductors of an electric machine or with the secondary terminals of an induction coil.

In the experiments detailed in this paper luminous effects are produced

under various other conditions, including especially the following cases : 1. When the tube is carefully insulated in a sealed glass envelope; 2. When the tube, thus insulated, is removed to a considerable distance from the exciting electric machine; 3. When the tube is subjected to friction without being exposed to any external electric field; 4. When the tube after being exposed to a strong electric field is removed therefrom and gently touched with the finger or breathed upon (after glow).

These and kindred observations have an important bearing upon the true character and mutual relations of electrical conduction and induction.

ACTINIC ACTION OF ELECTRICAL DISCHARGES. By Prof. THOMAS FRENCH, JR., Cincinnati, O.

[ABSTRACT.]

PHOTOGRAPHIC plates, carefully shielded from the direct action of light, were placed in the path of electrical discharges and then developed.

Various interesting effects were observed. When the centre of the sensitive plate was coated on both sides with tin foil, after the manner of a condensing plate, the sensitive film assumed, after development, a mottled appearance and discharge lines issued from all sides of the tin foil at right angles to the same.

IS CHEMICAL ACTION INFLUENCED BY MAGNETISM? By Dr. MORRIS LOEB, Clark University, Worcester, Mass.

[ABSTRACT.]

NUMEROUS experiments having been made to determine whether the deposition of crystals or the solution of magnetic metals was influenced by the presence of a magnetic field, it seemed of interest to ascertain whether chemical reactions, which would result in no alteration of the physical condition of the system, are thus influenced.

A study of the speed of oxydation of a ferrous salt, and of reduction of a ferric salt, showed that there was no perceptible difference between the results obtained *in* a magnetic field and *out* of it.

INDEX TO THE LITERATURE OF THERMODYNAMICS. By ALFRED TUCKER-MAN, Newport, R. I.

ON THE ADVISABILITY OF APPLYING THE CENTIMETER GRAMME SECOND SYSTEM OF ELECTRICIANS TO THE PRINCIPLES OF ELEMENTARY MECHANICS, SO AS TO HAVE THEM EXCLUSIVELY IN THE FUNDAMENTAL PHYSICAL CONCEPTIONS OF SPACE, MASS AND TIME. By P. H. VAN DER WEYDE, New York, N. Y.

SOME RESULT OF OBSERVATIONS MADE DURING THE RECENT "U. S. SCIENTIFIC EXPEDITION TO WEST AFRICA." By CLEVELAND ABBE, Washington, D. C.

EARTHQUAKE AND VOLCANIC PHENOMENA IN JAPAN. By Prof. THOMAS GRAY, Terre Haute, Ind. [This will be published in full in Report B. A. A. S. for 1890, Leeds Meeting.]

PLAN FOR A RESISTANCE BOX. By ALBERT L. AREY, Rochester, N. Y.

EXPERIMENTAL DETERMINATION OF THE RATE OF CHANGE IN UNDERGROUND TEMPERATURES AT THE DEPTH OF NINE FEET BY MEANS OF A FLOW OF WATER AT A CONSTANT LEVEL. By Prof. WM. A. ROGERS, Waterville, Me.

EVAPORATION AS A DISTURBING ELEMENT IN THE DETERMINATION OF THE TEMPERATURE OF WATER. By Prof. WM. A. ROGERS, Waterville, Me.

EXPERIMENTAL DETERMINATION OF THE TIME REQUIRED FOR WATER TO PASS FROM 42° TO 72° IN A CONSTANT AIR TEMPERATURE. By Prof. WM. A. ROGERS, Waterville, Me.

EXHIBITION OF A COMBINED METER WITH SUBDIVISIONS TO 2 MM. AND A YARD SUBDIVIDED TO TENTHS OF INCHES, BOTH BEING STANDARD AT 62°. By Prof. WM. A. ROGERS, Waterville, Me.

ON MAXIMUM TEMPERATURES. By Prof. A. E. DOLBEAR, Tufts College, Mass.

ON THE PHOSPHORIC LAMP. By Prof. F. W. VERY, Alleghany Observatory, Pa.

EXHIBITION OF VEMS' PHOTOGRAPHS IN NATURAL COLORS. By ORRAY TAFT SHERMAN, 379 Harvard Street, Cambridge, Mass.

DISCUSSION OF THE FORMULÆ INDICATING THE WORK OF AN ELECTRO-MOTOR. By G. W. HOUGH, Evanston, Ill.

DESCRIPTION OF A SERIES OF TESTS FOR THE DETECTION AND DETERMINATION OF SUB-NORMAL COLOR PERCEPTION (COLOR-BLINDNESS), DESIGNED FOR USE IN RAILWAY SERVICE. By CHARLES A. OLIVER, M.D., 1507 Locust Street, Philadelphia, Pa.

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ADDRESS

BY

ROBERT B. WARDER,

WASHINGTON, D. C.,

VICE-PRESIDENT, SECTION C.

RECENT THEORIES OF GEOMETRICAL ISOMERISM.

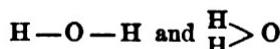
I. INTRODUCTION.

THE histologist places a section of organized tissue upon the stage of his microscope, and studies its structure. He reports upon the cells and their contents, for he has *seen* them, but he has not detected the molecule. The smallest discernible particle was probably an aggregate of at least a million molecules of elaborate structure, permeated by many times as many molecules of simpler composition.

The actual configuration of atoms in the molecule, the bonds by which they are united, the mechanism which effects transformations from one form to another,—and, indeed, the very existence of molecules, are subjects which do not belong to the world of sight. It is not likely that any human eye, with the most perfect optical instruments, will ever penetrate these secrets of an unseen world.

But the many unseen worlds are favorite hunting grounds of science. The imagination of the geologist sees successive strata in regular order or thrown into folds, where the rocks are hidden from the uninitiated by drift, soil and forest, or even where they were long since removed by erosion. The astronomer, having discovered a simple law controlling the motions of the planets, pursues them with the formulas of dynamics and perturbations, until the unexplained residuals of motion lead him to the very spot occupied by Neptune. The biologist experiments upon the vitality of invisible germs, but the chemist reasons upon the elements that make up molecules of

which these germs consist; he recognizes atoms having simple, double, triple and quadruple power of union; whatever be the nature of this union, the "bonds" are as *real* as ever held prisoner to Roman soldier. The structural formulas which characterize the language of modern chemistry express the fact that each atom is specially related to a certain one or more other atoms, with scarcely the least claim in regard to distance or direction. Thus, the formulas

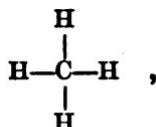


simply indicate that the connection between H and O is believed to be direct, while that between H and H is through the intervention of the O. The hydrogen atoms may lie in opposite directions from the oxygen, or they may be on the same side; their distance from each other may be twice as great as the distance of each from oxygen, or they may be in contact; all parts of the molecule may oscillate in distance and direction according to any conceivable law. The doctrine of valence and types prepared the way for the more elaborate doctrines embodied in structural formulas, which so admirably explain numerous reactions and isomers. Yet these give us no indication of the directions of the atoms from each other, and only the most vague intimation of distance or form. Normal pentane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$, has probably a longer and more slender molecule than tetramethyl methane, $\text{C}(\text{CH}_3)_4$; yet we do not know whether the single chain of carbon atoms is straight or crooked, and the formula for side chains does not show whether the second form approaches a sphere or a disc. Such is our ignorance of the actual relations of the atoms in space, that no photographs of geometrical isomers will be offered for your inspection; yet certain working hypotheses of their configuration, which were received for some years with great reserve, have recently had such influence in shaping the current of research in organic chemistry, that they are well worth our attention at this hour.

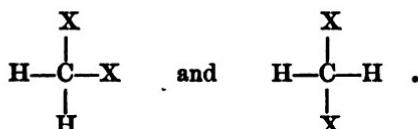
II. THE DOCTRINE OF ASYMMETRIC CARBON.

When the quadrivalent character of carbon was distinctly recognized, as in CH_4 , it was probably not long before the regular tetrahedron often occurred to thinking minds as a suitable representation. Without assuming that this is the true shape of the carbon atom, the four solid angles, symmetrically placed (or, pos-

sibly, the four faces) suggest the power of combining with four atoms of hydrogen, each of which could be replaced by other groups with like facility. If we write the structural formula for methane on a plane surface in the most symmetrical form possible,



we must distinguish a difference between a pair of *adjacent* and a pair of *opposite* hydrogen atoms, leading to the isomeric di-derivatives,



Such isomers are not known; and if we may depend upon this negative evidence, the four bonds of the carbon atom are *not* directed in one plane like the spokes of a wheel. The only possible arrangement in which two bonds shall have the same relation as any other two bonds, is that indicated by conceiving the atom of carbon at the centre of a regular tetrahedron, with bonds directed towards the four angles. Another mode of defining the same relations in space is to conceive the bonds as directed towards the centre of each face.

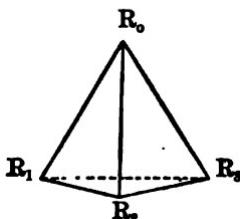


FIG. 1.

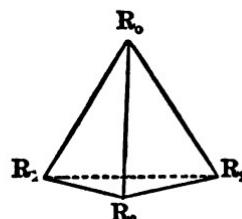


FIG. 2.

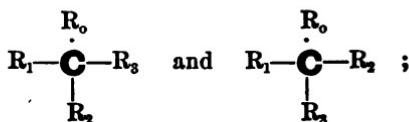
These two models¹ represent methane derivatives of the form $\text{CR}_0\text{R}_1\text{R}_2\text{R}_3$, the carbon being united to four different radicles.

¹ Colored balls connected by wires (as in Kekule's models) are preferred for lecture purposes. Meyer (Ber. 23, 572) recommends others for individual study.

Under such conditions, the carbon is said to be *asymmetric*. If R_0 is held towards us, the remaining radicles are seen in left hand cyclical order in fig. 1 and in the reverse order in fig. 2. The models are mutually symmetrical and equivalent, but not superposable. Each one differs from the other, just as it differs from its own image in a plane mirror. When crystals exhibit such differences in the position of their hemihedral faces, they are said to be enantiomorphous, and the same term may appropriately be used of the two models or the molecules which they represent.

A definite meaning must be given to certain words. A *structural* formula for a compound expresses the "bonds," or linkage, between its several parts in terms of the valence hypothesis, as determined by the reactions expressing decompositions and syntheses. These bonds are the same in figs. 1 and 2; both express the same structure. Yet there is a real distinction of known isomers, with identical structure, that can be most readily explained by means of geometrical extensions of the older theories; Wunderlich proposes the term *configuration* to denote these newer distinctions. V. Meyer¹ uses the term *constitution* to include both the structure, or constitution in the older sense, and the configuration, or *stereochemical* relations. Our hypotheses of configuration, or the relative position of atoms in the molecule, are based upon the careful study of *isomers having identical structure*; and even though the theories should require some modifications in the future, they are at present our best means of correlating numerous observed facts.

A bold-faced letter, **C** (suggesting to the eye the conception of solidity), may denote the atom of carbon with reference to its lines of affinity in space of three dimensions, and the distinction represented in the models (figs. 1 and 2) may also be expressed on a plane surface by the symbols

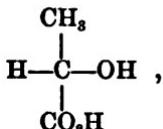


or, still more simply, thus :

$R_0\textbf{C}R_1R_2R_3$ and $R_0\textbf{C}R_1R_3R_2$, where the bold-faced **C** indicates that the order of the letters must be considered.

¹ Ber. 21, 789 (1888).

If CH_4 , thus represents the outline of a regular tetrahedron, it must not be supposed that the actual form is changeless, but rather that the *mean positions* of the hydrogen atoms are at the angles. In substitution products, we may think of the several radicles oscillating about mean positions that are at *unequal* distances from each other; the mutual attraction of the most unlike groups bringing them somewhat towards each other. The conditions in the two forms, however, are so far identical that the mean mutual distance of any pair of groups will be the same in both. The differences would not be likely to make one form more easily soluble or volatile than the other. The usual means of distinguishing isomers may fail. Ordinary methods of fractional distillation or precipitation are alike useless to distinguish bodies so nearly identical. If some power should endow our fingers with magnified tactile sense—magnified in proportion to our best microscopes—still we could not so handle these isomers as to detect a difference in their molecular form; but a most delicate instrument, capable of feeling the slightest resistance to the vibrations of luminiferous ether, is found in a ray of polarized light. When such a ray passes through the asymmetric molecule, it is probable that greater resistance will be met in some one plane than in another, and thus the plane of polarization is slightly turned. In a fluid aggregate, a ray will meet successive molecules in all possible positions; and while these must have unequal effects—sometimes, perhaps, in opposite directions, the mean result for a large number will always be the same. According to this hypothesis, the two isomers (being exactly alike except in the cyclical order of arrangement of the parts) should be right-handed and left-handed, with the same numerical factor. Wislicenus,¹ in a research upon paralactic acid, was convinced that two isomers of the same structural formula,



could only be explained by a different arrangement of the atoms in space; for such difference he suggested the name "geometrical isomerism." LeBel² and van't Hoff³ were the first to state clearly (and independently) the fundamental principles upon which this

¹ Ann. Chem. Pharm. 167, 343, 345 (1873).

² Bull. soc. chim. [3] 22, 337-347 (1874).

³"La chimie dans l'espace." Rotterdam, 1875.

branch of chemical investigation has been developed. In the first place, when carbon is linked with four different radicles, two isomers will usually result, the forms of the molecule being related to each other as an object to its image in a plane mirror. These isomers closely resemble each other in most physical and chemical properties. The following distinctions were noted by Pasteur,¹ in his studies of dextro- and laevo-tartrates, and he was convinced that the molecules themselves are enantiomorphous :—

1. The plane of polarized light is rotated equally in opposite directions.
2. The isomers disappear with unequal readiness when exposed in solution to certain lower organisms.
3. They combine with unequal readiness with other compounds containing asymmetrical carbon, and thus form compounds of distinctive physical properties.
4. Some pairs of isomers yield enantiomorphous crystals.

The new views were received with much coolness. The facts, as then understood, seemed to contradict the doctrine that optical activity depends upon asymmetric carbon, though it was supposed to depend upon vital processes. When van't Hoff's little book appeared in a German translation, with some additions by Herrmann, it was pursued by a torrent of ridicule² from a chemist who is no longer among us. To the facts originally adduced in support of this generalization, many others have since been added; while some apparent exceptions have been duly explained; such as propyl alcohol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, and cinnamene from storax, $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$, which were erroneously supposed to be active. Numerous derivatives of active bodies have been studied. Those which still contain asymmetric carbon are active; where the asymmetry of the carbon is removed, the rotatory power disappears. It was still noted that many bodies containing asymmetric carbon were inactive; but the new theory suggested new inquiries. Such bodies, like racemic acid, might contain both isomers in equal quantity; and the three methods that were used by Pasteur some forty years ago were now brought into requisition to separate them. Thus LeBel, using lower forms of vegetation, separated the constituents of propylene glycol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OH}$, propylene oxide, $\text{CH}_3\text{CH}(\text{O})\text{CH}_2$, and the two amylic alcohols, $\text{C}_3\text{H}_7\text{CH}(\text{OH})\text{CH}_3$ and $\text{C}_2\text{H}_5\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$. Bremer, adopting Pasteur's second method, half neutralized malic acid, $\text{CO}_2\text{H}\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$,

¹ See Bibliography appended.

² Jour. prak. Chem. 15, 473-477 (1877).

with cinchonine; which also contains asymmetric carbon, and therefore unites more readily with one of the isomers than with the other. The third method (by selecting the enantiomorphous crystals) is applicable to sodium ammonium racemate.

But if inactive bodies can thus be separated into their isomeric constituents, what shall we say of the loss of optical power when an active body is heated? Simply this, that during the more violent oscillations of the atoms in the molecule, some of the members become loosened and rearranged, so that a mixture of both isomers results, capable of being again separated, according to the usual methods. An equilibrium can be established when the isomers are present in equal amount (with total loss of active power) for then just as many exchanges will take place in one direction as in the other.

It would be of much interest to know, for a number of bodies, at what temperature the optical power begins to decrease; and to determine the rate of change as a function of the temperature. In such a research, we should trace the chemical "bond" loosening and reuniting; or we should at least see two bonds exchanging places under external force. A rather complicated example of such change, under the influence of an acid, has already been studied by Urech,¹ in the inversion of cane sugar.

III. TWO ASYMMETRIC ATOMS WITH SINGLE BOND.

Two such atoms may be represented by tetrahedrons, united at the corners, thus:

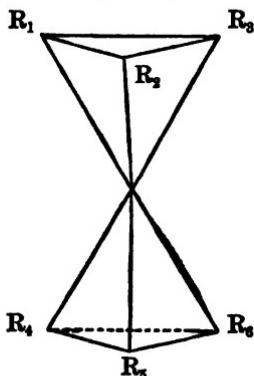
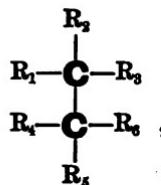


FIG. 3.

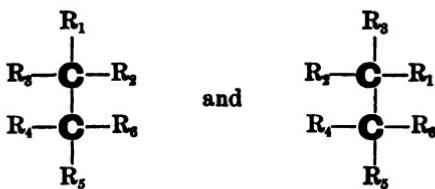
or



¹ Ber. 15, 3130-2133; 2457-2460 (1882) and 16, 762-766 (1883).

where it is important to note the *cyclical order* of the radicles attached to each carbon atom, *as seen from that atom itself*. Thus, in the plane formula, it is conventionally understood that the groups at the top and bottom of the diagram (R_1 and R_5) are supposed to be towards the front; and each set of three is represented in its true cyclical order upon the plane of the paper. If three radicles are thus immediately over the other three (as if the two tetrahedrons were inscribed in a right triangular prism) the pairs of radicles R_1 and R_4 , R_2 and R_5 , R_3 and R_6 , are said to be "in corresponding positions," or "plane-symmetrical."

Now we may conceive that either carbon atom, with the radicles attached, is capable of rotation about an axis joining the two, while the original cyclical order is preserved. Thus



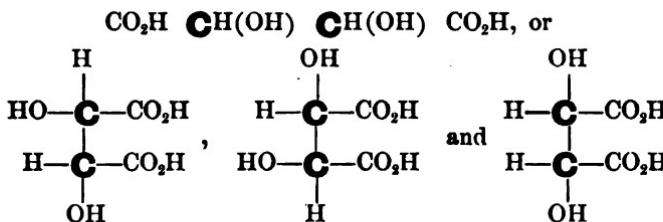
may be successive phases of the body already represented.

But we believe that each of the radicles, R_1 , R_2 , R_3 , is attracted (or repelled) by each of the others; and the moments thus arising may limit the freedom of rotation. We know but little of these forces except that unlike groups seem to attract each other most intensely. If R_1 and R_4 are strongly negative, and the rest positive, the first phase will be far less likely to occur than the second or third. In fact, there may be but one position of stable equilibrium, which the molecule always tends to assume. With another substance, there may be neutral equilibrium in all positions, with rotation in either direction, as the various impacts of molecules may determine; or, finally, there may be two or more positions of stable equilibrium, so that the molecule cannot pass from one of these configurations to another without some special application of external force. In this case only would the various phases represent isomeric modifications of the substance. Our theory must conform to the observed facts; otherwise we may either be overwhelmed with a multitude of imaginary isomers, or we may be unable to account for all that are discovered. The following principle (which has been known as "van't Hoff's second hypothesis")

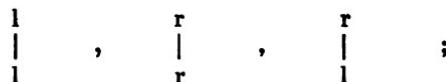
is supported by many facts:—When two atoms of carbon are united by a single bond, each is capable of free rotation in either direction about the common axis; and isomers may be recognized for those bodies only which cannot be brought into the same configuration by such rotation.

Some apparent exceptions must not be ignored, as the diphenic acids described by Schultz¹ twelve years ago. Leaving exceptions² out of account for the present, let us see what isomers are predicted by this general principle.

The best illustration of this class of bodies is found in the several tartaric acids



If we trace the cyclical order of the three radicles, H, OH, CO_2H , in each half molecule, these stereochemical formulas will exhibit the following character:



hence, the first two are assigned to ordinary and laevo-tartaric acids, while the third is believed to be inactive; the right hand effect of one-half the molecule being neutralized by the left-hand influence of the other half. It is still uncertain whether right-handed order of H, OH, CO_2H , or of OH, H, CO_2H , represents ordinary tartaric acid; hence, the first two formulas cannot be definitely assigned.

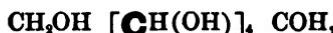
But, really, two inactive acids are recognized, racemic and meso-tartaric. The former can be separated into its active constituents by simply converting into the double salts of sodium and ammonium, crystallizing these, and carefully separating the two enantiomorphous forms. Racemic acid (like many inactive bodies already

¹Ber. 11, 216, and Ann. Pharm. Chem. 196, 24.

²These are discussed by Auwers and Meyer (Ber. 23, 2079-2083) who conclude that two or more positions of permanent equilibrium are capable of existence only in those cases where the substituting groups are nearly alike in negativity; hence, we need expect no great complication in our system of organic chemistry, arising from these phenomena. Of course the absence of isomers may be due either to "free rotation" or to a single position of stable equilibrium.

considered) is really a mixture or loose combination of r—r and l—l; while mesotartaric acid must have the third formula, or r—l. Metatartaric acid, if fully established, is not thus explained, and may be an exception to van't Hoff's hypothesis.

If the two asymmetric groups were not alike, still another isomer would be possible; for in the mixed type it is not indifferent which group is right-handed and which is left-handed. In general, if we have n asymmetric atoms of carbon, each distinguishable from all the rest, the number of isomers predicted by theory is the n th power of 2. Thus glucose,



may exist in sixteen isomeric forms; a complicated subject for study, but Fischer¹ has already marked one of the asymmetric atoms and obtained derivatives in which the asymmetry is removed, in order to trace the optical power of this particular atom. The work is in progress; and his recent lecture² on the synthesis of sugars, before the German Chemical Society, may show that the most intricate scientific investigation has important bearings upon our enjoyment of the social board, and the sweetness of a cup of tea.

IV. A MARKED EXCEPTION TO THE PRINCIPLE OF FREE ROTATION; OR STEREOKCHEMISTRY OF NITROGEN.

The exceptions already alluded to were not brought into prominence, until after the discussion of certain nitrogenous isomers, where it was quite possible to explain the leading facts by assuming a geometrical or polar character for the nitrogen atom. In the development of our theories, two widely different questions are thus closely linked.

Two years ago, K. Auwers and V. Meyer³ announced that the two orthobenzil-dioximes, have the same constitution, $\text{C}_6\text{H}_5\text{C}(\text{N}-\text{O}-\text{H})\text{C}(\text{N}-\text{O}-\text{H})\text{C}_6\text{H}_5$; in 1889, Stierlin⁴ described isomeric anisil-dioximes $\text{CH}_3\text{O}\text{C}_6\text{H}_4\text{C}(\text{NOH})\text{C}(\text{NOH})\text{C}_6\text{H}_4\text{OCH}_3$, and para-tolil-dioximes $\text{CH}_3\text{C}_6\text{H}_4\text{C}(\text{NOH})\text{C}(\text{NOH})\text{C}_6\text{H}_4\text{CH}_3$; and this year Hausmann⁵ has announced the corresponding isomers of mononitro-benzil-dioxime $\text{C}_6\text{H}_4(\text{NO}_2)\text{C}(\text{NOH})\text{C}(\text{NOH})\text{C}_6\text{H}_5$.

¹ Fischer & Hirschberger, Ber. 22, 365-376 (1889).

² Ber. 23, 2114-2141 (1890).

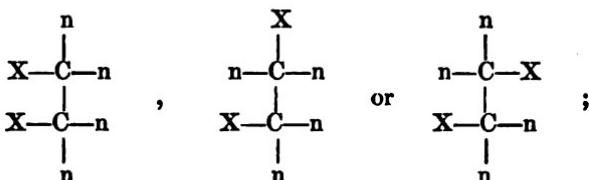
³ Ber. 21, 784-817; 3510-3539 (1888).

⁴ Ber. 22, 376-383 (1889).

⁵ Ber. 23, 531-534 (1890).

Auwers and Meyer have also described two isomeric benzil-monoximes,¹ C₆H₅ C(NOH) CO C₆H₅; and, at last, a third benzil-dioxime was discovered.²

The utmost care was taken to establish the chemical structure of these bodies. Beckmann,³ in the meanwhile, investigated two isomeric oximes of benzaldehyde, C₆H₅ C(NOH)"H; but the same line of experiments, by which these isomers were found to have different chemical structure, led Auwers and Meyer to assign the same structure to the oximes of benzil, and to attribute a stereochemical isomerism, depending upon the two carbon atoms in the carbonyl groups of benzil. If we let X represent the phenyl group and substitute n—n for the bivalent group, N—O—H, benzil-dioxime, may be written



but (according to van't Hoff's theory, and the evidence of a large number of compounds studied) only one of these could be recognized as a definite stable structure. It will readily be seen, in fact, that there is no asymmetric carbon, and even such optical isomers as we find in tartaric acid are excluded; whereas, these isomers differ in melting point, solubility and stability. The discoverers are therefore led to assume that in this case, at least, the C₆H₅ and NOH groups are so nearly alike in electro-chemical sense, that several positions of stable equilibrium are possible. The second and third of these formulas present too little difference to account for the third isomer with its distinctive properties, as observed; hence, still other positions are supposed, which may be derived from fig. 3 by turning the upper tetrahedron through various angles.

In fig. 4, each free corner of the upper tetrahedron is represented above the middle of a basal edge of the lower one. Instead of placing the pairs of radicles, R₁ R₄, etc., in corresponding positions (that is, in a line parallel to that joining the centers of the tetrahedrons) they are placed in opposite, or *center-symmetrical* positions, as though either tetrahedron had been rotated 180°. To fa-

¹ Ber. 22, 557-561 (1889).

² Ber. 22, 705-720 (1889).

³ Ber. 22, 429-440, and four later papers.

cilitate printing, an equivalent formula is suggested which does not require special cuts.

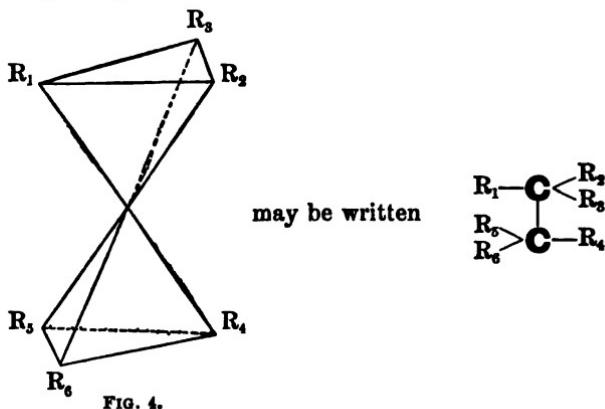
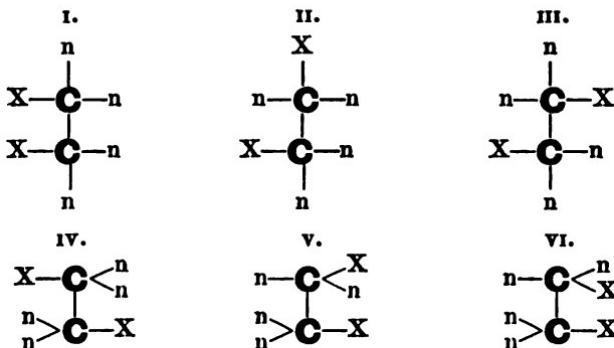


FIG. 4.

Here (as in the conventional plane formula for fig. 3) the radicles at the front corners of the tetrahedrons, R_2 and R_6 , are assigned to the highest and lowest positions, as though we were looking at each triangle from the carbon. With this understanding, the plane diagram will show the same cyclical order as fig. 4; but it should be remembered that R_2 and R_6 (not R_2 and R_4) have positions of symmetry with regard to the center of the diagram.

On this hypothesis, six isomeric dioximes may exist, thus :



The configurations II and III, V and VI, are enantiomorphous, hence it seems probable that the bodies of each pair thus represented may be indistinguishable in most of their properties; and Meyer interprets his formulas (which may be considered as horizontal projections of those given above) to predict four isomers only.

Auwers¹ gives a full review of the whole subject, and suggests that the three dioximes known may represent three positions of stable equilibrium, namely :

1. Plane-symmetrical, phenyl groups having corresponding positions, as R₁ R₄ of fig. 3.

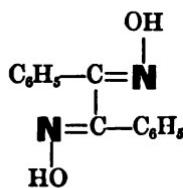
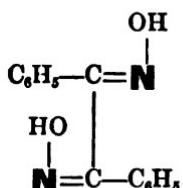
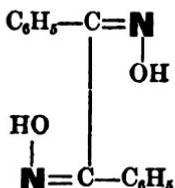
2. The two enantiomorphous configurations derived by rotating half the molecule 90° in either direction.

3. The center-symmetrical form, which would result by rotation 90° further; phenyl groups having opposite positions, as R₁ R₄ of fig. 4.

The first of these configurations, as the least stable, is assigned to γ-benzil-dioxime.

Still another hypothesis in regard to the nature of the bonds, or "dipoles," is offered by Meyer and Riecke,² to show why the free rotation of some compounds with unlike radicles may be lacking in those whose radicles are of nearly equal positive or negative character.

The modification of van't Hoff's hypothesis is also ably defended by Meyer³ in a lecture given before the German Chemical Society last January, while other chemists attribute the isomerism to nitrogen. Two closely related theories have been offered; the first, by Hantzsch and Werner,⁴ the other by Behrend.⁵ Under the former theory, the three lines of affinity do not lie in the same plane, and the hydroxyl may be turned either towards or from that carbon atom to which the other NOH group is united. The bonds of N essentially represent a convex and a concave surface. For this geometrical conception, the second theory substitutes that of polarity, one side of the surface being positive, the other negative. The essential feature of Hantzsch and Werner's theory may be represented in the following formulas for the dioximes, using the symbol **N** for nitrogen considered in its stereochemical relations :



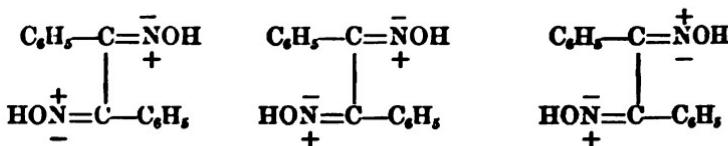
¹ "Die Entwicklung der Stereochemie." Heidelberg, 1890; pages 52-133.

² Ber. 21, 946-956 (1888).

⁴ Ber. 23, 590-614 (1890).

³ Ber. 23, 454-458 (1890).

This theory plainly gives the same number of isomers as that of Behrend, whose formulas may be slightly modified (for the sake of comparison) as follows:



The compounds of carbon seldom exhibit well authenticated examples of geometrical isomerism, except with asymmetrical carbon, with double bond between carbon atoms, with a closed ring, or with the presence of nitrogen. If further researches prove that geometric isomerism depends upon nitrogen, both the theories offered for this element may be equally true; but, for the present, the problem of the oximes of benzil can hardly be considered as settled.

Bischoff¹ has just presented a still different view, assuming hydroxylamine as $\text{H}_3\text{N}=\text{O}$.

V. CARBON ATOMS WITH DOUBLE OR TRIPLE BOND.

Again, using the tetrahedron as the symbol of the carbon atom, we may conceive two such forms united on a common edge, with hydrogen at the four free corners, to represent the molecule of ethylene. Any non-saturated body, regarded as a substitution product of ethylene, would be

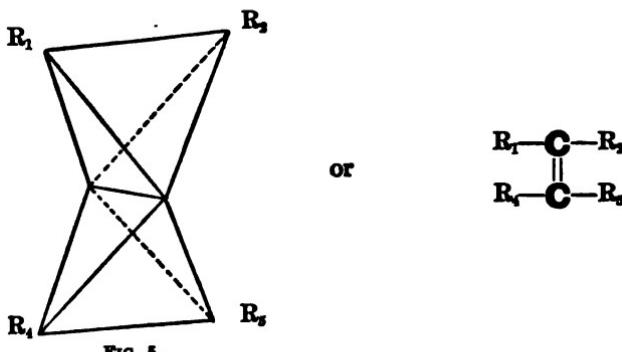
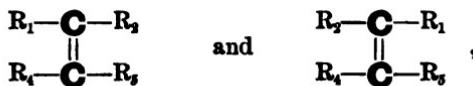


FIG. 5.

or, more simply still, $\text{C}(\text{R}_1\text{R}_2)$ $\text{C}(\text{R}_4\text{R}_5)$.

¹ Ber. 23, 1967-1973 (1890).

The double bond might, *a priori*, admit of rotation, just as well as the single bond; for the tetrahedral symbol is really an admission of ignorance concerning the actual nature or location of the bond's exerted. Experiment, not speculation, must decide whether the body $\mathbf{C}(R_1R_2)$ $\mathbf{C}(R_4R_5)$ is the same as $\mathbf{C}(R_2R_1)$ $\mathbf{C}(R_4R_5)$. Now in fact there are a great many such pairs of isomers, including the old puzzle, so hotly contested, of maleic and fumaric acids. These facts are most readily explained by supposing that if a plane be conceived as determined by the parallel lines of affinity in the double bond, R_1 and R_4 of fig. 5 will be on one side while R_2 and R_5 are on the other. The two arrangements,



both represent conditions of stable equilibrium, and one cannot be changed to the other without some external force.

In like manner, acetylene derivatives may be represented by two tetrahedrons with a common face, thus :

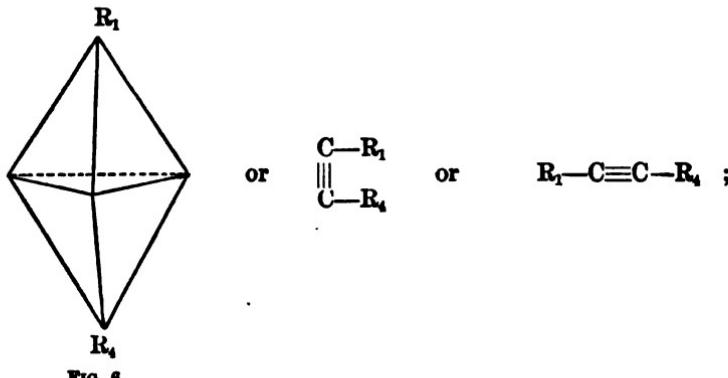
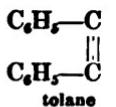
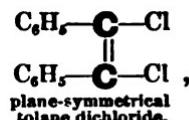


FIG. 6.

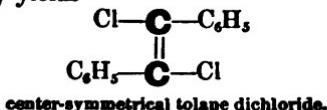
where ordinary structural formulas tell the whole story, and geometrical isomers are neither predicted by theory nor found in practice. These are of great value, however, in certain cases, to investigate the configuration of other molecules; Wislicenus has pointed out that in the formation of an addition product by loosening one of the bonds, the original groups, R_1 and R_4 , must occupy corresponding positions, while the two radicles added must do the same. For example, by the simple addition of Cl_2 ,



yields



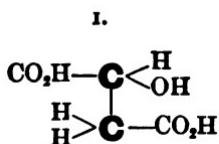
and only indirectly yields



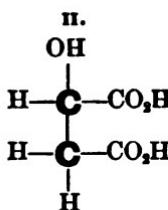
The isomers are distinguished as plane-symmetrical (with reference to a plane separating the carbon atoms) and center-symmetrical (with regard to the center of the molecule) as explained above with figures 3 and 4. The former is regarded as the "unfavorable configuration," like radicles being relatively near each other. The dynamic theory of partial change by heat into the center-symmetrical modification is well illustrated by Eiolart.¹

In like manner, in addition products of $\text{C}(\text{R}_1\text{R}_2)\text{C}(\text{R}_4\text{R}_5)$, the radicles added may have corresponding positions at the first moment; but, on the principle of free rotation, a change will probably take place, so that for the mean position of the atoms, unlike groups will be brought as near as possible, and like groups as far as possible. These hypotheses will be better understood with the aid of a concrete example.

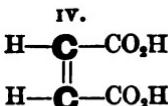
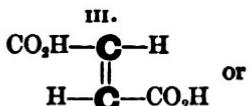
Malic acid (which may be written²



or



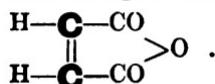
or in any similar form, resulting from rotation of half the molecule) loses water by heating to 150° or 200° and may yield either



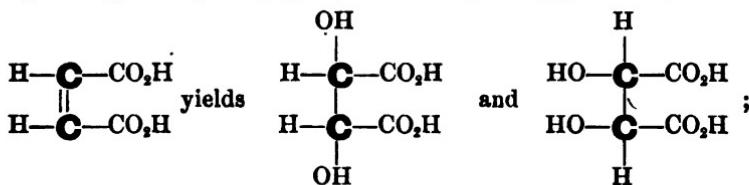
¹ Amer. Chem. Jour. 12, 281-253 (1890).

²These formulas represent, of course, only one of the isomers. The other would have the groups H, OH, CO_2H , in reverse cyclical order; but the same results follow with both.

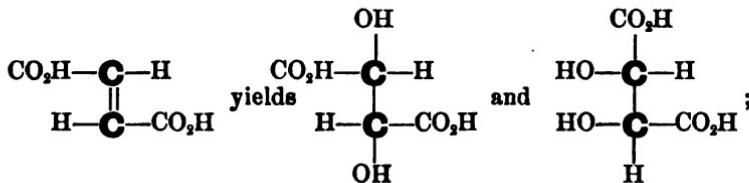
Two bibasic acids are found as the result of the experiment, known as fumaric and maleic, of which the former predominates. Are we justified in adopting these two formulas? And which should be assigned to each? We may suppose that in a mass of malic acid, a greater number of molecules would have the carboxyl groups turned somewhat from each other, as in I, than turned on the same side of the C₂ axis, as in II; the former is the "more favorable position," especially when the atoms are not agitated by excessive temperature; hence, in the product, we should expect a larger share of III than of IV. Further, we should expect to get the anhydride of IV, more easily than that of III; and when found, the anhydrides of both should have the same configuration,



If the double bond should become loosened by heat or other agencies, thus permitting of any rotation, we should expect CO₂H to attract H, thus IV would be more likely to turn into III than the reverse. All these features, having been observed in the laboratory, confirm the stereochemical hypothesis, and lead us to assign formula III to fumaric, and IV to maleic acid. To the evidence derived from all these facts, a most interesting confirmation is added in the oxydation products when the two acids are treated with permanganate. By adding two hydroxyl groups at corresponding positions,

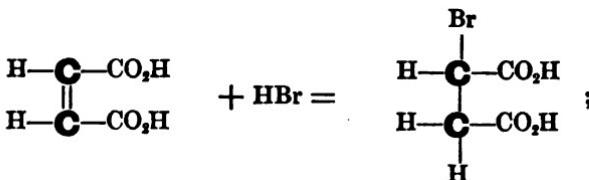


maleic acid yields tartaric acid of the l—r or r—l type,—that is, mesotartaric acid. But, by the same process,



fumaric acid yields tartaric acid of the l—l and r—r types, that is, racemic acid.

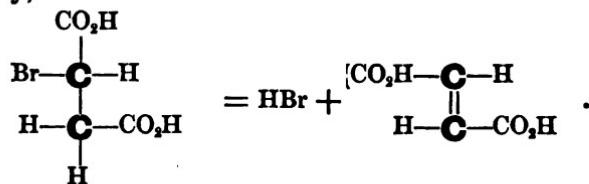
There is one difficulty in which we must still wait for a satisfactory solution. Maleic acid is converted into fumaric by simple contact with strong acids, especially fuming hydrobromic acid. Wislicenus attempts to explain this by assuming the temporary formation of bromsuccinic acid, thus:



by rotation,



and, finally,



The difficulty is that bromsuccinic acid is stable and does not yield fumaric acid in presence of fuming hydrobromic acid; but while the theory may still be weak in a few points, it so beautifully correlates a multitude of facts in regard to a multitude of non-saturated bodies, that it seems needless caution to adhere to the expression "alloisomerism" adopted by Michael, which simply means an isomerism other than that illustrated in ordinary structural formulas.

It may be added that when olein is converted into elaidin by contact with nitrous acid, a similar change from less favorable to more favorable configuration is probable.

VI. THEORY OF RINGS.

When a chain of atoms forms a closed ring, certain limitations arise, as already noticed for the formation of maleic anhydride.

Theories of configuration have stimulated the study of the benzene-nucleus,¹ the lactones, etc. In hexamethylene, we have six atoms of carbon, with two of hydrogen attached to each. If substituting radicles are attached to two of the carbon atoms, they may either be on the same side or on opposite sides of the plane of the ring, according to the analogy of maleic and fumaric acids. v. Baeyer, using the Greek letter Γ to indicate geometric isomerism, calls the former Γ^{cis} or Γ^{c} and the latter, Γ^{trans} ; that is, "geometrically on this side, on this side," and, "geometrically on this side, on the further side." But we must hasten to the last part of the subject.

VII. THEORIES OF FORM AND FORCE, ATOMS AND BONDS.

The fullest discussion of the carbon atom, as a solid body, is probably that of Wunderlich.² v. Baeyer discusses bonds in connection with his study of rings. Meyer and Riecke's theory of dipoles has already been mentioned. Naumann offers a theory of tensions in relation to thermochemical data. Sachse and Loschmidt each suggest various forms for rings, with directions for the construction of models to illustrate the forms described. A campaign is thus being conducted towards the stronghold of atomic mysteries. It has been stated that hereafter physics must take the lead in such investigations, but pure physics stops with the molecule. I have endeavored briefly, and with no claim to originality of thought, to indicate the manner of approach from the chemical side. As the astronomer must make due allowance for the aberration of light and a star's proper motion before he can reach out a measuring line and determine its distance by parallax, so the chemist must multiply his compounds and test their reactions on all sides, before he can announce with certainty the discovery of geometrical isomers, as determined by the *residual* facts, inexplicable on other grounds. A part of the theory has been so firmly established, that it must hereafter be recognized in chemical science. Various hypotheses are even now being weighed in the balances. Still other speculations represent the ideals of earnest thinkers; in the absence of clear evidence concerning the nature of atoms, bonds and valence, it is well to make use of such hints as we can; and, perhaps, in the distant future, all may become clear.

¹ v. Baeyer, Ann. Chem. Pharm. 245, 103-100 (1888); 251, 257-311 (1889), etc.

²"Configuration organischer Molecule," Würzburg, 1886. An outline of this theory is given in Auwers' "Entwickelung," pages 27-35; a brief abstract in Ber. 19, Ref. 692.

BIBLIOGRAPHY.

The current theories of stereochemistry or geometrical isomerism are based upon those residuals of observed facts that find no explanation in the usual doctrine of structural formulas. Any complete bibliography, covering all the experimental evidence that may bear upon this subject, must therefore include all reactions or properties that aid us in determining the constitution of the many compounds capable of appearing in geometrical isomers. In the following list, an attempt is made to include those papers only that may be most useful to chemists or physicists desiring to acquaint themselves with the history of the stereochemical conception, its originators, supporters and opposers.

The papers have been classified with regard to the subject matter and author, and the same reference may belong to more than one head. A chronological arrangement is followed, only in subordination to this classification. The succession of topics is similar to that in the foregoing paper.

Most of the references in van't Hoff's "Dix années dans l'histoire d'une théorie" (for example, the seven papers discussing the optical character of cinnamene) are not repeated here; and I have not worked up the references in Wilslicenus' "Räumliche Anordnung der Atome."

I am indebted to the courtesy of Mr. A. W. Whelpley for special facilities in consulting the Cincinnati Public Library.

I. General Considerations and Fundamental Principles.

WISLICENUS.—Ann. Chem. Pharm. **107**, 302-346 (1873). Paralactic acids.

See, especially, pages 343-345; with note by Meyer, in Berichte **23**, 568 (1890).

LEBEL.—Bull. soc. chim. [2] **22**, 337-347 (Nov., 1874). A pioneer effort, largely quoted in van't Hoff's "Dix années."

VAN'T HOFF.—Bull. soc. chim. [2] **23**, 295-301 (1875).

" " "La chimie dans l'espace," Rotterdam, 1875.

VAN'T HOFF-HERRMANN.—A German translation of the same, edited by Herrmann, appeared in 1877 as "Die Lagerung der Atome in Raum."

VAN'T HOFF.—A second French edition of "La chimie dans l'espace" entitled "Dix années dans l'histoire d'une théorie," Rotterdam, 1887. This quotes (on pages 18-17) from an unnamed Dutch pamphlet, by the same author, of September, 1874.

CLARKE.—Amer. Chemist **6**, 81–84 (1875) and Proc. A. A. A. S. **24**, 99–107.
“Chemistry of three dimensions.”

WUNDERLICH.—“Configuration organischer Molecule,” Würzburg, 1886.
See Berichte **19**, Ref. 592 (1886).

WISLICENUS.—Abh. Kgl. Sächs. Gesel. der Wissenschaften **14**, 1–78 (1887).
“Ueber die räumliche Anordnung der Atome in organischen
Moleculen und ihre Bestimmung in geometrisch-isomeren un-
gesättigten Verbindungen.” The same is printed separately.
A second edition, with references to more recent papers, ap-
peared in 1889.

LOSSEN.—Ber. **20**, 8306–8310 (1887).

MEYER.—Ber. **23**, 567–619 (1890). “Ergebnisse und Ziele der stereochem-
ischen Forschung.”

AUWERS.—“Die Entwicklung der Stereochemie.” Habilitationsschrift,
Heidelberg, 1890.

The papers of van't Hoff (or van't Hoff-Herrmann), Wislicenus, Meyer
and Auwers are especially recommended as an introduction to the general
subject.

II. Asymmetric Carbon and Optical Character. Separation of Isomers.

PASTEUR.—Ann. chim. phys. [3] **24**, 442–459 (1848); **28**, 56–99 (1850), and
38, 437–487 (1858). Compt. rend. **37**, 162–166 (1858) and **46**,
615–618 (1858). Tartrates, separation of racemic acid, etc.

“ ‘Lecons de chemie,’ Paris, 1861, page 25. Theorem that atoms
in these molecules must constitute non-superposable forms,
related like object and image.

GERNEZ.—Compt. rend. **63**, 843 (1866). Separation by crystallization.

“ Compt. rend. **104**, 783–785; **105**, 808–806 (1887); **106**, 1527–
1530 (1888); **108**, 942–945 (1889) and **110**, 529–532; 1365–
1368 (1890). Influence of molybdates and tungstates.

LANDOLT.—“Das optische Drehungsvermögen,” Brunswick, p. 28 et seq.

OSTWALD—Lehrbuch, **1**, 469–474.

PIUTTI.—Asparagines, etc. See part II, b.

BAMBERGER.—Ber. **23**, 291–292 (1890). Ac. tetrahydronaphthylenediamines.
Separation with aid of tartaric acid. Enantiomorphism.

GUYE.—Compt. rend. **110**, 714–716; and Ber. **23**, Ref. 888. Chemical
constitution and optical power.

See further references in van't Hoff's “Dix années.”

II. a. Application to the Sugar Group.

FISCHER and HIRSCHBERGER—Ber. **21**, 1805–1809 (1888) and **22**, 365–376;
8218–3224 (1889). Mannose.

FISCHER.—Ber. **23**, 379–381 (1890). Mannonic acid separated by strychnine.

“ Ber. **23**, 799–805 (1890). Synthesis of grape sugar.

FISCHER.—Ber. **23**, 2114–2141 (1890). Lecture on synthesis of the sugar group; with bibliography of this subject.

FISCHER and PASSMORE.—Ber. **23**, 2226–2239 (1890).

This subject has also been reviewed by Keiser, in Amer. Chem. Journ. **11**, 277 (1889), and **12**, 367 (1890).

II, b. Application to Alkaloids, etc.

LADENBURG.—Ber. **19**, 2578–2582 (1886). Synthesis of conine.

" Ber. **21**, 3065–3070 (1888). Atropine.

LADENBURG and HUNDT.—Ber. **22**, 2590–2592 (1889). Decomposition of tropic acid by quinine.

ANTRICK.—Ber. **20**, 310–322 (1887). Cocaine and polarized light.

WILL.—Ber. **21**, 1717–1726 (1888). Atropine and hyoscyamine.

WILL and BREDIG.—Ber. **21**, 2777–2797 (1888).

SCHMIDT.—Ber. **21**, 1829 (1888).

LIEBERMANN and GIESEL.—Ber. **23**, 508–512 (1890). By-products of cocaine manufacture.

PIUTTI.—Gazz. chem. **18**, 457–485 (1888), and Ber. **22**, Ref. 241–245. Asparagines, etc.

EINHORN.—Ber. **22**, 1495 (1889).

EINHORN AND MARQUARDT.—Ber. **23**, 468–474 (1890). Dextro-cocaine; its physiological action is more prompt and more transient.

III. Carbon Atoms with Single Bond.

Many of the following papers discuss apparent exceptions to the hypothesis of "free rotation," in non-nitrogenous bodies. See Auwers' discussion of this principle in his "Entwickelung," pages 134–157. Papers on the oximes are indicated in part IV.

PASTEUR.—Tartaric acids; see II.

SCHULTZ.—Ber. **11**, 216–218 (1878) and Ann. Chem. Pharm. **196**, 1–33 (1879.) Diphenic acids.

GRAEBE and AUBIN.—Ber. **20**, 845–848 (1887). Diphenic acids.

GRAEBE.—Ber. **20**, 848–850 (1887). Formulas for the same.

GRAEBE and JUILLARD.—Ann. Chem. Pharm. **242**, 214–257 (1887). Dipthalic acid.

GRAEBE and JUILLARD.—Ber. **21**, 2003–2005 (1888). Benzilorthocarboxylic acids.

GRAEBE.—Ber. **23**, 1344–1349 (1890). Isomeric benzilorthocarboxylic acids. Meyer's theory for the oximes is applied to these on p. 1347.

DEMUTH and MEYER.—Ber. **21**, 264–270 (1888). Isodibromsuccinic acid.

BETHMANN.—Zeitsch. physik. Chem. **5**, 408–417 (1890). Succinic acid and homologues.

BISCHOFF, with others.—Ber. **23**, 631–656; 1942–1950 (1890). Substituted succinic acids.

- AUWERS and MEYER.—Ber. **23**, 2079–2083 (1890). Stereochemistry of ethane derivatives.
 AUWERS and JACKSON.—Ber. **23**, 1599–1617 (1890). Bischoff's "dynamical isomerism."

IV. Nitrogen Compounds. [For alkaloids, see part II, b.]

- VAN'T HOFF.—"Ansichten über die organische Chemie," pages 79–81, 1881.
 WILLGERODT.—Jour. prak. Chem. **37**, 449–454 (1888). Hydrazines.
 " Jour. prak. Chem. **41**, 291–300; 526–528 (1890).
 BURCH and MARSH.—Jour. Chem. Soc. **55**, 654–664 (1889). The dissociation of amine vapors.
 AUWERS and MEYER.—Ber. **21**, 784–817; 3510–3529 (1888). Two isomeric benzil-dioximes.
 " Ber. **22**, 537–551 (1889). Isomeric benzil-monoximes.
 " Ber. **22**, 564–567 (1889).
 " Ber. **22**, 705–720 (1889). The third benzil-dioxime.
 " Ber. **22**, 1985–1995 (1889). No isomeric oximes were obtained from phenanthraquinone.
 AUWERS and DITTRICH.—Ber. **22**, 1996–2011. Structure of monoximes.
 AUWERS and MEYER.—Ber. **22**, 3005.
 AUWERS.—Ber. **23**, 399–403.
 " "Die Entwicklung der Stereochemie," pages 52–133. Oximes of benzil.
 MEYER.—Ber. **23**, 590–618 (1890).
 AUWERS and MEYER.—Ber. **23**, 2063–2064; 2403–2409 (1890). Oximes and hydroxylamine.
 STIERLIN.—Ber. **22**, 876–888 (1889). Isomeric dioximes of anisil and paratolil.
 HAUSMANN.—Ber. **23**, 531–534 (1890). Isomeric dioximes of mononitrobenzil.
 E. HOFFMAN.—Ber. **23**, 2064–2066 (1890). Isomeric dioximes of cuminil.
 BECKMANN.—Ber. **22**, 429–440; 514–517; 1531–1536; 1588–1597 (1889), and **23**, 1680–1692 (1890). Benzaldoximes.
 JANOVSKI and REIMANN.—Ber. **22**, 40–45 (1889). Para-azoxytoluenes.
 JANOVSKI.—Ber. **22**, 1172–1176, and Ref. 752; Monatsh. f. Chem. **10**, 583–601 (1889). Azoxytoluenes.
 GOLDSCHMIDT.—Ber. **22**, 8101–8114 (1889), and **23**, 2168–2180 (1890). Oximes.
 GOLDSCHMIDT and MEISSLER.—Ber. **23**, 258–280 (1890). See part VIII.
 BEHREND and LEUCHS.—Ber. **22**, 384–386; 613–618 (1889), and Ann. Chem. Pharm. **257**, 203–247 (1890). Hydroxylamine derivatives.
 BEHREND.—Ber. **23**, 454–458 (1890). Theory of polarity.
 HANTZSCH and WERNER.—Ber. **23**, 11–30; 1243–1253 (1890). Stereochemistry of nitrogen.
 HANTZSCH.—Ber. **23**, 2322–2338 (1890). Unsymmetrical oximes.
 WERNER.—Ber. **23**, 2383–2386 (1890). Oximes of benzoin.
 " Ber. **23**, 2386–2393 (1890). Ethers of oximes.

- ZINCKE.—*Ber.* **23**, 1821 (1890). Geometric isomerism with pentivalent nitrogen.
- LEBEL.—*Bul. soc. chim.* [8] **2**, 805 (1889), and *Jour. Chem. Soc.* **58**, 228. Methyl-ethyl-propylamine hydrochloride is optically inactive.
- GATTERMANN.—*Ber.* **23**, 1738–1787 (1890). Isomerism of nitrogen compounds.
- GATTERMANN and RITSCHKE.—*Ber.* **23**, 1738–1750 (1890). Azoxyphenol ethers.
- BISCHOFF.—*Ber.* **23**, 1967–1972 (1890). Stereochemistry of nitrogen.
- “ *Ber.* **23**, 1972–1976 (1890). Piperazine group.

V. Carbon Atoms with Double Bond.

- WISLICENUS.—“Raumliche Anordnung, etc.” See part I.
“ *Ber.* **20**, 1008–1010 (1887). Derivatives of crotonic acids.

- The next six papers embrace researches in the Leipsic laboratory, under Prof. Wislizenus.
- WISLICENUS.—*Ann. Chem. Pharm.* **246**, 53–96 (1888). Fumaric and maleic acids.
- BLANK.—*Ann. Chem. Pharm.* **248**, 1–34 (1888). The stilbene group.
- WISLICENUS.—*Ann. Chem. Pharm.* **248**, 281–355 (1888). Crotonic acid and halogen substitution products. Reply to Michael. [Compare *Jour. prak. Ch.* [2] **38**, 6–39.]
- “ *Ann. Chem. Pharm.* **250**, 224–254 (1889). Angelic and tiglic acids.
- EIOLART.—*Amer. Chem. Jour.* **12**, 232–253 (1890). Chlorine compounds of tolane.
- ALEXANDER.—*Ann. Chem. Pharm.* **258**, 67–86 (1890). Phenylmalic acids.
- LEBEL.—*Bull. soc. chim.* [2] **37**, 300–302 (1882). Maleic and fumaric acids.
- ERLENMEYER.—*Ber.* **19**, 1936–1938 (1886). Cinnamic acid series.
- ANSCHÜTZ.—*Amer. Chem. Jour.* **9**, 253–269 (1887). Fumaric and maleic acids.
- ANSCHÜTZ and SELDEN.—*Amer. Chem. Jour.* **9**, 379–385 (1887), and *Ber.* **20**, 1382–1388 (1887). Monobromcinnamic acids.
- ANSCHÜTZ.—*Ann. Chem. Pharm.* **239**, 161–184 (1887). [See *Ber.* **20**, 1388].
- “ *Ann. Chem. Pharm.* **254**, 168–182 (1889).
- MICHAEL.—*Amer. Chem. Jour.* **9**, 180–204 (1887). Alloisomerism.
- MICHAEL and BROWNE.—*Amer. Chem. Jour.* **9**, 274–289 (1887). Alloisomerism.
- MICHAEL.—*Amer. Chem. Jour.* **9**, 364–372 (1887). Levulinic and maleic acids.
- MICHAEL and BROWNE.—*Jour. prak. Ch.* [2] **35**, 257–260 (1887), and **36**, 174–176 (1887). Crotonic acid series.
- MICHAEL and PENDLETON.—*Jour. prak. Chem.* [2] **38**, 1–5 (1888). Crotonic acid series.

- MICHAEL.—*Jour. prak. Ch.* [2] **38**, 6-39. *Criticisms of Wislicenus.*
 [Compare *Ann. Chem. Pharm.* **248**, 342-355.]
- OSTWALD.—*Zeitsch. phys. Chem.* **3**, 241 (1889). *Constants of electric conductivity.*
- WISLICENUS and HOLZ.—*Compt. rend.* **108**, 405 (1889). *Dibromsuccinic acid.*
- LIEBERMANN.—*Ber.* **23**, 141-156; 512-516 (1890). *Isocinnamic acid.*

VI. *Theory of Benzene and Other Rings.*

[See, also, part VII.]

- v. FEHLING's *Handwörterbuch*, **1**, 1136-1144.
- WATTS' *Dictionary*, revised, **1**, 451-454.
- KEKULÉ.—*Bull. soc. chim.* **3**, 98-110 (1865).
 " *Ann. Chem. Pharm.* **137**, 129-196 (1866).
- CLAUS.—"Theoretische Betrachtungen und deren Anwendung zur Systematik der org. Chemie." *Freiburg*, 1867.
- " *Ber.* **15**, 1405-1411 (1882), and **20**, 1422-1426 (1887).
- " *Jour. prak. Ch.* [2] **37**, 455-464 (1888), and **40**, 69-77 (1889).
- LADENBURG.—*Ber.* **2**, 140-142; 172-174 (1869).
 " " *Theorie der aromatischen Verbindungen.* *Brunswick*, 1876.
 " *Ber.* **19**, 971-978 (1886), and **20**, 62-65 (1887).
 " *Ann. Chem. Pharm.* **248**, 382-384 (1888).
- R. MEYER.—*Ber.* **15**, 1823-1828 (1882). *Octahedral formula.*
- J. THOMSEN.—*Ber.* **13**, 1888, 1808-1811, 2166 (1880), and **15**, 328-331 (1882).
 " *Ber.* **19**, 2944-2950 (1886). *Octahedral formula.*
- v. BAEYER.—*Ann. Chem. Pharm. Suppl.* **7**, 1-55 (1870). *Mellitic acid.*
 " *Ber.* **18**, 674-681; 2269-2277 (1885). *Polyacetylene compounds.*
 " *Ber.* **19**, 1797-1810 (1886).
 " *Ann. Chem. Pharm.* **245**, 108-190 (1888), and **251**, 257-311 (1889), and **256**, 1; **258**, 1-49; **258**, 145-219 (1890). *Constitution of benzene.*
- A. K. MILLER.—*Jour. Chem. Soc.* **51**, 208-215 (1887). *Review of v. Baeyer and Thomsen.*
- BRÜHL.—*Zeitsch. physik. Chem.* **1**, 307.
 " *Ber.* **20**, 2288-2311 (1887).
- VAN'T HOFF.—*Maandblad voor Naturwetenschappen* **6**, 150.
- HERRMANN.—*Ber.* **21**, 1949-1959 (1888), and **23**, 2060-2062 (1890). *Benzene and Hexamethylene.*
- TILDEN.—*Jour. Chem. Soc.* **53**, 879-888 (1888). *Terpenes and benzol.*
- BECKMANN.—*Ann. Chem. Pharm.* **250**, 322-375 (1889). *Camphor series.* Theoretical part, pages 360-375.
- KÖNIG.—"Zur Theorie und Geschichte der fünfgliedrigen Kohlenstoffringe." *Leipsig*, 1889, 80 pages. This contains an estimate of the relative distance of carbon atoms, with single and double bonds.

BISCHOFF.—Ber. **23**, 620–623; 656–659 (1890). Anhydrides of substituted succinic acids.

SWORN.—Phil. Mag. [5] **28**, 402–415; 443–451, and Jour. Chem. Soc. **58**, 238.

VII. *Mathematical Conceptions of Form and Force.*

BERTHELOT.—Bull. soc. chim. [2] **23**, 388–340 (1875). Necessity for considering rotary and vibratory movements.

v. BAUER.—Ber. **18**, 2277–2281 (1885). Theory of rings, double bond and triple bond. Compare NOYES, Amer. Chem. Jour. **11**, 496 (1889).

WUNDERLICH.—“Configuration organischer Molecule.” See part I.

WISLICENUS.—Ber. **21**, 584 (1888).

MEYER and RIECKE.—Ber. **21**, 946–956 (1888). Theory of bonds, as electrical “dipoles,” to account for lack of free rotation in oximes of benzil.

NAUMANN.—Ber. **23**, 477–484 (1890). Theory of tensions for double and triple bonds.

SACHSE.—Ber. **21**, 2530–2538 (1888). Abstract in Amer. Chem. Jour. **11**, 132–134. Configuration of benzene nucleus.

SACHSE.—Ber. **23**, 1362–1370 (1890). Hexamethylene derivatives. Models for the carbon nucleus.

ASHE.—Chem. News **60**, 235 (1889). Hypothetical constitution of atoms.

KÜNIG.—See part VI.

LOSCHMIDT.—Monatsh. f. Chem. **11**, 28–32, and Ber. **23**, Ref. 275, and Wien. Sitzungsber. **99** (1890). Theory of carbon ring.

BISCHOFF.—Ber. **23**, 623–630. Theory of mechanical hindrance to free rotation with single bonds.

LEBEL.—Bul. Soc. chim. [8]; **3**, 788–796. Equilibrium of saturated compounds.

VIII. *Desmotropy, or Tautomeric Compounds.*

The possible migration of atoms must be duly considered in deducing structural formulas; and as Laar's curious theory of interchangeable bonds affects some of the investigations of geometric isomers, the following references to this topic are appended.

LAAR.—Ber. **18**, 648–657 (1885), and **19**, 730–741 (1886).

MEYER.—Ber. **20**, 1732, foot-note.

HANTZSCH and HERRMANN.—Ber. **20**, 2801–2811 (1887), and **21**, 1754–1758 (1888).

HERZIG and ZEISEL.—Monatsh. f. Chem. **9**, 217–226; 882–889, and **10**, 144–155. Ber. **21**, Ref. 437, 797, and **22**, Ref. 404.

BÖNIGER.—Ber. **21**, 1758–1765 (1888).

NEF.—Amer. Chem. Jour. **11**, 1–17 (1889), and **12**, 879–425 (1890). Ann. Chem. Pharm. **258**, 261–818 (1890).

GOLDSCHMIDT and MEISSLER.—Ber. **23**, 253–280 (1890).

EIGHTH ANNUAL REPORT OF THE COMMITTEE ON INDEXING CHEMICAL LITERATURE.

THE Committee report the publication of the following works :—

1. Index to the Literature of the Butines and their Halogen Addition Products (1863-1889). By Mr. Arthur A. Noyes, in the Technological Quarterly, Boston, for December, 1888. This should have been noticed earlier, but owing to the absence of the author, now in Europe, it was overlooked; it comprises an author- and a subject-index; the abbreviations used are those of the Standard List prepared by this committee.

2. Index to the Literature of Thermodynamics. By Dr. Alfred Tuckerman. Miscellaneous Collections of the Smithsonian Institution, No. 741, Washington, D. C., 1890, pp. vi-289. [Subject-index, Author-index.]

3. Index to the Literature of Amalgams. By Prof. Wm. L. Dudley, in his Vice-Presidential Address to the American Association for the Advancement of Science at Toronto. Proceedings A. A. A. S. for 1889, pp. 161-171, 1890, 8vo.

4. A Bibliography of Analytical Chemistry for 1888. J. Anal. Chem. III, 1889.

5. The same for 1889. J. Anal. Chem. IV, 1890.

6. A Bibliography of Chemistry for the year 1886. Smithsonian Report for 1886-87, Washington, 1889.

These brief bibliographies (4, 5, and 6) are by Dr. H. C. Bolton.

7. Professor A. A. Breneman, in an Historical Summary to his memoir on the fixation of Atmospheric Nitrogen (J. Am. Chem. Soc. xi), gives many bibliographical data.

The "Index Pharmaceuticus," published in the *Pharmaceutical Era* (monthly), and noticed in our sixth annual report, grows in scope and value. It is an alphabetical subject-list of original papers and important reprints and abstracts appearing in thirty-two periodicals, English, American, French and German. Although pharmacy is dominant, chemical topics are often included. The subject-index is followed by an author-index, referring to the former.

The committee further report that several volunteer indexers are making progress. Dr. Alfred Tuckerman is engaged on an Index to the Chemical Influence of Light, and is planning more work of great value. Dr. James Lewis Howe is indexing the metals of the platinum group. Dr. H. C. Bolton reports progress on a Select Bibliography of Chemistry, which is an extension of the Bibliography of Historical Chemistry previously noticed; in the enlarged plan he is being assisted by Dr. Alfred Tuckerman.

As often stated in these annual reports, the Committee limits its duties to the encouragement of volunteer indexers, and to chronicling work performed. The fact that undertakings announced several years ago have not been recently noticed does not always indicate their abandonment; many will undoubtedly be brought to completion by their authors. Many chemists who are willing to contribute their quota to the general scheme are, however, deterred from making definite offers by the inadequacy of the libraries to which they have convenient access. This difficulty is a real one, and suggests that much might be accomplished by coöperation of several persons in a single subject, each indexing the sets of periodicals available, and submitting the partial work to one of the number for editing. In such an enterprise conference between the several chemists uniting on a given topic would be necessary to avoid duplication and to secure a uniform plan.

Prof. W. O. Atwater, director of the office of the experiment-stations, Department of Agriculture, in conference with the committee calls attention to the desirability of securing bibliographies and indexes to certain topics in the chemistry of plants and animals, such as: (1) chemistry of albuminoid compounds; (2) chemistry of the so-called amid-compounds, and kindred bodies; (3) chemistry of the fatty bodies; (4) chemistry of the lecithins, waxes, chlorophylls, chloresterin, etc.; (5) chemistry of the carbohydrates—these to meet a need which is being more and more keenly felt by physiological and agricultural chemists.

Subsequent to the presentation of this report, the Chemical Section authorized the introduction of the following minute:

After a discussion in the Section on the continuance of a Committee to confer with others with a view to founding a National Chemical Society, Dr. Prescott suggested as a proper function of such a society the publication of an Index to Periodical Chemical Literature. He deprecated the multiplication of periodicals and maintained the utility and importance of an index to the contents of those already in existence.

Respectfully submitted,

H. CARRINGTON BOLTON, *Chairman*,

F. W. CLARKE,

ALBERT R. LEEDS,

ALEXIS A. JULIEN,

JOHN W. LANGLET (in Europe),

ALBERT B. PRESCOTT.

REPORT OF COMMITTEE UPON A NATIONAL CHEMICAL SOCIETY.

At the Toronto meeting of the Association, a committee consisting of Messrs. Prescott, Hart and Springer, presented a report upon the subject of a National Chemical Society. They pointed out, quite clearly, the desirability of such an organization, but formulated no definite plans; and accordingly a new committee was designated to secure further evidence as to the practicability of the project. The present report, therefore, is to be regarded as an appendix to or continuation of the very able and conservative document presented to the section by Dr. Prescott last year.

In order to secure a positive expression of opinion from American chemists, the chairman of your committee, acting also as chairman of a like committee from the Chemical Society of Washington, issued, jointly with Prof. H. W. Wiley, representing the Association of Official Agricultural Chemists, a circular letter, a copy of which is affixed to this report as an appendix. That circular was widely distributed, and to it 107 replies have been received. Of these replies 94 were favorable to the formation of a National Society; 7 were doubtful, and 6 definitely opposed. In this enumeration the resident members of the Washington society do not appear, for it was thought best to avoid any accumulation of local interest in the figures returned. The Washington Society, however, has voted unanimously in favor of the measure, and so, too, at its last meeting, did the Association of Official Agricultural Chemists. In all, so far, about 250 chemists have expressed their approval of the general plan.

On matters of detail, such as the publication of a journal, the formation of local sections, and the status of the existing American Chemical Society, the replies differ widely. A large majority of the respondents regard a journal as essential to the success of a society; most of them favor the idea of local sections; and in general a close affiliation with the American Association is well recommended. Some of the replies are very full in their discussion of the question; and many valuable suggestions have been made. The success of the Mining, Mechanical and Civil Engineers in their several Institutes was more than once cited as evidence in favor of a national organization for Chemistry.

As regards the publication of a journal, many chemists urge the importance of taking some established periodical, as a suitable basis of action ; or, better still, the consolidation of two or more such organs in one. The multiplication of journals is generally deprecated ; and in this opinion your committee heartily concur. That a society, if formed, must maintain a journal, is clear ; but the plan of operations cannot be fully made out beforehand. The existing journals depend for their success upon their clientage of chemists, and any strong movement on the part of the latter will be responded to by the publishers. There should be no real difficulty and no serious conflict of interest in solving this part of our problem if once a vigorous society is formed.

Since the last meeting of this section, stimulated apparently by its action, the American Chemical Society has shown renewed activity. Hitherto, in spite of its claims to national standing, that society has been essentially a local organization, with headquarters in New York, and more than half its membership in or near that city. Recently, however, it has adopted a revised constitution, which provides for the organization of local sections elsewhere, and assigns to them a fair share in the government of the whole body. The headquarters of the society still remain in New York ; there the annual meetings must always be held, and so far it continues to be local in character. It is, nevertheless, an important factor in the problem before us, inasmuch as it occupies a portion of the field, and has claims that are justly entitled to respectful consideration.

On August 6 and 7, barely two weeks ago, the American Chemical Society held a summer meeting at Newport, at which the chairman of your committee was present by invitation. During the meeting the movement for a larger national organization was fully discussed, with the best of feeling and in the broadest possible spirit. In behalf of its own title to national standing that society urges its continued existence for fourteen years, its publication of a journal, and the building up of its library ; and it can also show from the list of its presidents that there has been no discrimination in favor of New York and against chemists of other localities. It has surely been national in spirit, though local by force of circumstances. Towards the movement which we have instituted it is in no wise hostile ; and it seems quite clear that by means of mutual concession of a wholly minor sort a union with it can be effected. It was

proposed at Newport that a conference of chemists should be called during the coming winter, at some comparatively neutral point, in which all interests should be represented, and in calling such a conference this section should share. To the proposal that the consolidated national society should hold its annual meetings practically at the same time and place as the American Association, thereby strengthening the latter and building up this section, the New York chemists do not object; on the contrary, they seem to regard the plan with favor. The name of the American Chemical Society might well be retained by the enlarged organization, and the possession of the library should be left to the New York section, which also would have rank of seniority above the other branches. Furthermore, New York might fairly remain the business headquarters of the society, and the established journal of the American Chemical Society could serve as a basis upon which the new society should build. These are suggestions, merely thrown out for future consideration.

In conclusion your committee recommend that this section join with the American Chemical Society, the Chemical Society of Washington, and other like organizations, in calling a conference of chemists to be held at some time during the coming winter. The purpose of that conference shall be to decide how a national organization can best be brought about, and the long-desired union of all American chemists made a practical reality. The obstacles in the way of speedy success are now small and few, and if the American Chemical Society can be included in the movement, the new association should start with at least five hundred members.

Respectfully submitted,

F. W. CLARKE,
H. CARRINGTON BOLTON,
E. HART.

NOTE. Not signed by Professors Warder or Ellis. The latter could not be reached.

APPENDIX.

CONTINENTAL CHEMICAL SOCIETY.

TO THE CHEMISTS OF AMERICA.

The undersigned, representing committees appointed by the Chemical Society of Washington, the Chemical Section of the American Association for the Advancement of Science, and the Association of Official Agricultural Chemists respectfully submit the following statement:

During the past two years the formation of a National, or rather Continental Chemical Society has been much discussed. A committee, of which Prof. A. B. Prescott was chairman, presented a report upon the subject at the last meeting of the American Association, and that report was in the main favorable. A new committee, however, was appointed to secure fuller information, and will report at the next meeting of the Association, in August, 1890, at Indianapolis. A larger attendance of chemists is there expected.

The plan which has so far been chiefly considered is, in brief, as follows:

To organize a Continental Chemical Society, representative of all North America, by affiliating together as far as possible existing local organizations. The society as a whole to hold an annual meeting at such time and place as may be agreed upon from year to year; while local sections, like the Sections of the British Society for Chemical Industry, shall have their regular frequent gatherings in as many scientific centres as possible, all publishing their work in one official journal.

Bearing this rough outline in view, will you kindly state whether you regard the project favorably, and if modifications or objections occur to you, will you formulate them? Do you favor a society at all? Do you favor the idea of local sections? Do you favor the publication of a journal?

Upon the basis of the replies to this circular the committees named in it will prepare their reports to the organizations which they represent. Other existing societies, having appointed similar committees, may take action independently; if so, their views will be considered also, as it is desirable to secure the fullest coöperation among the chemists of America. Complete unity of action is essential to success.

Very respectfully,

F. W. CLARKE,
H. W. WILEY.

Please address replies to Prof. F. W. Clarke, U. S. Geological Survey, Washington, D. C.

REPORT OF COMMITTEE FOR PROMOTING THE USE OF THE METRIC SYSTEM AMONG PHYSICIANS AND PHARMACISTS.

In view of the seventh decennial meeting of the convention for the revision of the U. S. Pharmacopœia, held at Washington, D. C., May 5, 1890, your committee felt that it was very desirable to have their address laid before that convention. It was, accordingly, prepared, printed, and distributed to the members, and widely published in the professional journals. In addition, the committee secured the delivery of an address by the president of this Association, Prof. Mendenhall, who volunteered for the purpose, and whose efforts, we believe, had much to do with the final successful result. It is also due to Dr. D. W. Prentiss of Washington, a member of this Association, to say that he worked most earnestly in the committee on revision and elsewhere, to effect the purpose for which we were appointed.

It would of course be difficult to say just how much the work of the committee effected, in securing the adoption of the metric system in the Pharmacopœia, which the convention resolved upon, but it is commonly consented that the efforts of your committee have largely contributed to produce that result. Assuming that this step will never be retraced, it is probable that it is one of the most important yet taken in the progress towards the universal adoption of the metric system. The address is here reprinted.

REPORT OF THE COMMITTEE ON AN ADDRESS IN FAVOR OF THE METRIC SYSTEM DIRECTED TO THE PROFESSIONS OF MEDICINE AND PHARMACY, AND THE MEDICAL AND PHARMACEUTICAL COLLEGES OF THE UNITED STATES AND CANADA.

At the last meeting of the American Association for the Advancement of Science, held at Toronto, Canada, September, 1889, the undersigned were appointed a committee to promote the use of the metric system of weights and measures among professional men and especially to secure its more general adoption by the physicians and pharmacists and the chemical and pharmaceutical manufacturers of our country.

The metric weights and measures were legalized in this country by Congress in 1866, and are now in actual use by most students of natural history, by some scientific periodicals, by the graduates of our schools of civil and mining engineering, and especially by all scientists and chemists throughout the world, without regard to their mother tongue. It is nevertheless greatly to be regretted that a large majority of our physicians, pharmacists and druggists still continue to ignore its merits or discountenance its adoption.

The merits of the metric system have been so thoroughly recognized that it is adopted by most civilized nations. Further argument should be unnecessary to secure its universal adoption in our hemisphere, where it is already in exclusive use by all the states of Southern and Central America.

It is a strange and irreconcilable fact that the governments of Great Britain and the United States, or the English-speaking peoples, should stand quite alone in their stubborn and persistent adherence to the use of heterogeneous standards of weights and measures, completely devoid of system in themselves, or of any practical and rational relationship to each other. And it is especially strange, in view of the practical utility of the metric system, that the professions of medicine and pharmacy in this country should, in this respect at the present time, be behind the various arts of engineering, as must be conceded by those familiar with the facts.

This condition of things is not due to any inherent defects in the system itself, but to indolence and a want of practical acquaintance with the metric system which largely amounts to positive ignorance, that is unjustifiable, since it hinders the proper assimilation of the great mass of scientific literature in which the system is exclusively used, tends to increase the risk of errors in our professional work and imposes much unnecessary labor on the students.

The educated representatives of medicine and pharmacy in this country favor and would gladly adopt the metric system, but find their efforts in this direction constantly hampered and nullified by the opposition of a large number of both professions, who, through conservatism or lack of education, fail to unite in any concerted effort for its more general adoption and use.

It is unnecessary here to expatiate on the advantages of the metric system of weights and measures. The identity of the single

factor with our system of numeration, the perfect correspondence between measures of weight and capacity, its approval by a large majority of the nations of the world, and especially its actual use by scientists and chemists without exception, render its ultimate adoption by all arts dependent on natural sciences, and especially by medicine and pharmacy, a matter of necessity and certainty. Its adoption is not to be viewed as an experiment as would be such modifications of our present forms as have been proposed by some individual enthusiasts, and which have received but little consideration by any but their inventors.

The argument that our system of weights and measures is the same as that in use in Great Britain, with whom we have most intercourse, is without foundation. The system we use is well called the *American system*, for no other nation uses it. The *Troy* pound has been abolished in Great Britain, and no longer appears in their text books, and the fluid measures are different in the proportion of 4 to 5.

If identity is to be preserved between our measures and those of any other nation, some change must be made, and we believe there is substantial unanimity in a preference for the metric system in place of our old system if any change is made.

It is wholly unnecessary to defer the adoption of this much needed reform until the prejudices, fallacious arguments, or educational deficiencies manifested by a large contingent of pharmacists and physicians shall have been overcome. Such a period must necessarily be remote and indefinite, while the method herein proposed avoids any delay. The difficulty of securing any change on the part of men already in active business is well shown by the fact that the simple innovation in the present U. S. Pharmacopœia, of expressing quantities in *parts by weight*, demonstrates that a great many pharmacists are incapable of comprehending so simple a relationship when applied to the complicated empirical and antiquated systems of weights and measures in present use.

One of the principal reasons why the metric system has not yet been adopted in this country by professional men is the indifference shown by our professional schools. Every student of medicine and pharmacy is practically obliged to learn a system of weights and measures new to him when he begins professional study. He may have learned the apothecary tables in his schooldays, but he has not used them, and as elements of thought the grain and drachm

are entirely new to him. If the gram and cubic centimeter are substituted for them, no additional labor is entailed upon the student. It must not be supposed at the present time that professors who are really competent, are ignorant of this system, and hence this change would not entail any additional labor on the professors. In fact, it would diminish the labor of both professors and students, for in medical schools, at the present time, instruction is given in both systems, and it would simply make the methods of instruction uniform, in the chairs of *materia medica*, *pharmacy* and *chemistry*, where now is confusion.

The *Pharmacopœia* does not now recognize the *Troy* system, and if the doses were taught in metric terms only, the old system would die out with the passing off of the present generation of practitioners. No inconvenience would be caused to any one; those who are too old to learn could go on using their present mode, and the new graduates would use that which they are taught.

It should be particularly remembered that we are not trying to introduce a new system but to drop an old one, which is as irrational and unscientific as any other relic of barbarism. *It is especially opportune at this time when a new revision of the Pharmacopœia of the United States is pending, that the committee of revision, as well as the pharmacists, druggists and physicians of this country should have their attention particularly directed to this important subject.* For the use of these professions, six lines contain all that is necessary, as follows:

1000 milligrams make one gram.

1000 grams or cubic centimeters make one kilo or liter.

1000 kilos make one ton.

65 milligrams make one grain.

15½ grains make one gram.

31 grams make one ounce *Troy*.

In writing prescriptions, a vertical line should be drawn between grams and milligrams, all figures on the left read grams, all on the right to three figures, respectively deci-, centi-, and milligrams.

Chemists think in milligrams and grams only, and pharmacists and physicians may do likewise, reducing our system to two denominations. In the arts the milligram is not divided.

As the metric system is legal throughout the United States any physician is entitled to present a metric prescription to the drug-

gist. All boards of examiners in medicine and pharmacy, whether state or collegiate, are justified by law to exact, and *should demand from every candidate for graduation or for a license, a knowledge of the metric system.*

We also earnestly recommend that schools of medicine cease to give instruction in the apothecary system of weights and measures for which there is no longer any reason, and that in the schools of pharmacy the merits of the metric system should be presented with the prominence that its utility, and the near prospect of its adoption justify, in the best way to secure its immediate use as the exclusive system of weighing and measuring in medicine and pharmacy, and in the manufacturing arts correlative with them. And for the further promotion of this object, we recommend that an addition be made to the pharmacy laws now in force in most of our states, prescribing that all persons receiving a license to sell drugs and dispense medicines shall be required to provide themselves with a set of metric weights and measures.

This convention is the sixth national association which has endorsed the metric system, the others being as follows:

International Photographers' Congress.

National Association of Builders.

American Institute of Architects.

American Society of Civil Engineers.

American Society of Microscopists.

After the convention, it seemed expedient to commend it still more strongly to professional men, which was done by an additional circular, as given below. The address and the circular are now in process of distribution to all the medical societies of the country.

TO PHYSICIANS AND PROFESSORS OF THERAPEUTICS, MATERIA MEDICA AND PHARMACY.

The adoption of the metric system as the only system to be used in the next edition of the U. S. Pharmacopœia, which has occurred since the accompanying address was prepared, justifies the committee of the American Association for the Advancement of Science in asking you to carefully consider this circular, and the address sent herewith.

It is universally conceded that this system will be everywhere adopted for all scientific and professional application. The arguments or reasons urged against the system in its relations to the mechanic arts have no application to its use in medicine and pharmacy. Some have proposed to

wait for further legislation, but no act of Congress or other legislative body in this country can go further toward securing its adoption than has already been done.

It is the only system which has been legalized by Congress.

All others are permissive only, and are, strictly speaking, unauthorized by the government of the United States. Public opinion at the present time would not tolerate in this country compulsory measures as adopted by some European governments for its introduction.

The metric system has already been some time in use in the Post Office, the Coast Survey, the U. S. Navy, and the Marine Hospital service, and measures are now before Congress to introduce it still more extensively into government work. Students should note that a thorough knowledge of the system is required to enter the U. S. Navy or Marine Hospital service.

It being admitted that the system will be adopted, it is plain that the sooner it is done, the shorter time shall we have the inconveniences and friction due to the contemporaneous existence and struggle of two systems. Neither government laws, association resolutions, nor discussions only, will secure the abandonment of the old weights and measures and the use of the new ones. This must be done by each individual making himself acquainted with, and actually using, the metric system in his thoughts and applications. It may perhaps require a little effort for the older members of the profession to do this, but we most earnestly ask the younger members of the medical profession and recent graduates to use the metric system exclusively in prescribing.

At the present time there is no danger of loss or disadvantage in doing this. It is the only legal system throughout the United States, and as the system of the Pharmacopœia, it will be the official system that carries weight of authority. At the present time it is actually in use by a number of physicians, throughout the land, of native as well as of foreign birth. Several colleges of medicine give instruction from their chairs of *materia medica* in the metric system only. All text-books used in teaching medicine should contain doses, etc., in metric terms.

The actual and intrinsic advantages of the metric system in the arts of medicine and pharmacy are very considerable. The terms used in the old system number at least four, viz., the *grain*, *scruple*, *dram* and *ounce*. To these are really to be added the *minim* and *fluid ounce*. The fluid ounce and the dry ounce are not the same, and the factor of each denomination is different, making four factors to remember and compare each time a prescription is written. If the metric system is used, there is *but one factor*, viz.: the *gram*, which is divided according to our ordinary or decimal system of numeration.

The gram is the essential thought unit. As the cubic centimeter of water weighs one gram, the units of weight and measure are identical, and only the specific gravity of fluids lighter or heavier than water (of which there are not many used in medicine) needs to be considered.

As each sign and factor is a separate idea, there are at least ten distinct thought elements in the old system against one in the new, and as the

chance of error is as the number of terms, the possibility of making a mistake is ten times greater in the old system than in the metric, given equal practical knowledge of each system in the practitioner.

Again the hieroglyphic signs for scruple, dram and ounce are abolished by the metric system, and the possibility of confusion between the last two vanishes. Also the V and X of the *Roman* numerals give place to the *Arabic* numerals 5 and 10 in common use. The former characters are not unfrequently written in such a way as to be easily mistaken for each other, and this source of error, too, is removed by abolishing the use of the Roman characters.

The following is an example of a metric prescription:

Doctor's address.

Office hours.

Metric prescription.

R	Morphiæ Sulph.	0	06
	Chloralis.	6	
	Syrupi.	25	
	Aquaæ, ad.	100	

Sig. tablespoonful every four hours until relieved.

On the back of the prescription blank may be printed:

Metric System in Medicine.

Grams. Decimals.

One grain or one minim equals	0	06
15 grains or 15 minims equals	1	
1 dram or 1 fluid dram equals	4	
1 ounce or 1 fluid ounce equals	32	

The cubic centimeter (cc.) may be considered equal to the gram for water or aqueous solutions.

Liquids lighter or heavier than water should either be weighed or a proper allowance made.

An ordinary teaspoon when full contains five cubic centimeters, a dessert spoon fifteen, and a tablespoon twenty cubic centimeters.

As the metric system has for many years been in universal and exclusive use by chemists, the weights and measures are for sale by all wholesale houses. Fluid measures are easily obtained with the metric measures on one side and the old system on the other.

Wm. H. SEAMAN,

FRED. HOFFMAN,

ROBERT B. WARDER.

REPORT OF THE COMMITTEE ON SPELLING AND PRONUNCIATION OF
CHEMICAL TERMS.

YOUR committee sent out to American chemists, in May, 1889, a provisional list of terms used in chemistry, arranged alphabetically, with a request for criticism. To this twenty-six replies were received. These were carefully digested, and a report, based upon these replies and upon a very thorough study of the subject, was presented to the Chemical Section at the Toronto meeting in 1889. The presentation of the report was followed by an extended discussion on the general principles involved and by provisional decision in the case of many individual words and classes of words. The report was revised after the meeting so as to contain the recommendations of the Chemical Section and was then printed and circulated among the members of the Association and American chemists generally, with the request for further criticism and suggestion. This elicited thirty additional communications, many of which, as in the preceding year, were of an elaborate nature and evinced the results of careful study of the subject from both the philological and the scientific standpoints. These letters, as well as many verbal assurances, testified to the earnest desire existing among our fellow chemists to have fixed rules of pronunciation replace the existing irregularities, divergencies and uncertainty.

The material, thus accumulated, was carefully collated and classified and submitted to the Chemical Section at the Indianapolis meeting. Provisional action was taken on a number of individual words, but as time did not permit of the full discussion of all cases the committee was requested to prepare a further list, limited to such words or classes of words as had evoked marked divergence of views and circulate this among American chemists, prior to the meeting of the Association in 1891, for a still further expression of opinion.

In conformity with this request, the accompanying list has been prepared. It includes all the rules and categories of words given in the report to the Toronto meeting, but the pronunciations of individual words as enumerated in that report are, with rare exceptions, omitted, unless they have evoked opinions, at variance with the recommendations of the committee from *more than one* correspondent. It is assumed by the committee, as a general rule, that all spellings and pronunciations, given in the two lists thus far printed,

which have not been criticised, are in harmony with the usage of American chemists.

As the list is limited, brief indications of the reasons for divergent views are frequently appended, and the authorities referred to are indicated by abbreviated initials, the full list of which is given at the end of the report. Words approved by votes at the Toronto meeting are indicated by a single asterisk; those approved at the Indianapolis meeting by a double asterisk. The numbers following the asterisks represent the vote where there was a division.

It is extremely desirable that the next report of the committee should be thoroughly representative and therefore the co-operation of all American chemists is earnestly sought. It is hoped that every chemist will carefully examine the list and plainly note *all variations* in spelling and pronunciation from the form recommended by the committee which may seem to him desirable and, as far as possible, give reasons in support of his views. It will be assumed that all rules or words in the committee's list, *not criticised* in a reply, are approved by the writer.

We trust, through the general and painstaking assistance of our fellow chemists, to obtain this year a valuable fund of material, showing the prevalent feeling and usage with regard to orthography and pronunciation, which will serve as the basis for final, definite recommendations to the Association and later for propositions leading to unity of action with the chemists of Great Britain.

In conclusion, it might be mentioned that the recommendations of the committee, as embodied in their report to the Toronto meeting, were discussed by the American Philological Society at their annual meeting at Norwich, July, 1890, and, in general, met the approval of that body.

You will confer a favor by sending your reply to the chairman of the committee within a fortnight after the reception of this report.

THOMAS H. NORTON, *Chairman,*
University of Cincinnati,
H. CARRINGTON BOLTON,
New York,
EDWARD HART,
Lafayette College,
JAMES LEWIS HOWE,
Polytechnic Society, Louisville, Ky.,
Committee.

GENERAL PRINCIPLES OF PRONUNCIATION.

1. The pronunciation should be as much in accord with the analogy of the English language as possible, yet continental pronunciation should be approached, inasmuch as it is used by a large proportion of the world's chemists and by a continually increasing number of American chemists.
2. Present usage should be retained as far as possible.
3. Derivatives should keep as far as possible the accent and pronunciation of the root word, in order to make the original sense as clear as possible. This is subordinate to Rule 1.
4. Distinctly chemical compound words should retain the accent and pronunciation of each portion.
5. Similarly sounding endings for dissimilar compounds should be avoided, hence -In, -Id, -Ite, -Até.
6. Utility often determines usage even when contrary to analogy.

PREFIXES.

GENERAL RULE. All prefixes in strictly chemical words should be considered as parts of compound words, and hence should retain their own pronunciation, unchanged.

- ä'ceto- ** Mc (ä'ceto-, Ws, favors è in all compounds of acet-) (ace'to-, Sh).
 äni'do- ** 18 to 10, Cl (amí'do-, Da, Br, Ny, Bo) (ä'mido-, * Ws).
 ä'zo- äni'do- ** (-amido-, Da, Br, Ny).
 i'so- **, Br, Ny, Ws, Do (i'so , Ho, Nr, Mr).
 mö'no- ** (mö'no, Mc, general usage in dictionaries).
 ni'tro- **, Cl Br, Ny, Mc, Ht, Wo, Ws, Do, Nr (ni'tro-, Da).
 nitro'so- **, Br, Ny (ni', Da).

NON-METALS, ETC.

- ö'xygen (ö'x- error in last report).
 äni'dogen, ** 18 to 4, Br.
 chlô'rín } *, **, 22 to 11, Mc, Ba, Bu, Nr.
 brô'min } (chlorine, etc., Cl, Da, Ny, T, Do).
 i'odin } (chlorine, etc., Mr, Wr).
 flû'orin
 sü'lfur and f in all derivative compounds, ** 20 to 10, Se; harmonizes our spelling with that of all other civilized languages.
 arsë'nicum, to be dropped as unnecessary ,** Cl, Br, E, Ws.

METALS.

Usage has determined the pronunciation except in a few instances.
 ma'nganese (es and not ez) ,** 80 to 1, Cl.

Fäte, fät, fär, mête, mët, pine, pln, marfne, nöte, nöt, möve, tübe, tüb, rüle, mÿ, ÿ = I.

' Primary accent; " secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

Words in *-um* have antepenultimate accent, and the vowel of this syllable is short if *t* or *y*, or if before two consonants, but long otherwise.

alū'minum, * 8 to 2, **, 22 to 10, Cl, Br, T, Hs, Pe, O, R. H. Clapp, —trade designation, harmonizes accent with alumina and aluminum (*alumi'nium*, Bo, Ho, Da, Ny, Nr, Ba, Ws, on account of euphony and harmony with the nomenclature of nearly all elements discovered this century).

beryl'lum (Cl, should be superseded by *glucinum* which has clear priority).

caē'sium (Ws proposes cesium, in harmony with Fr. *césium* and It. *cesio*).
irid'ium, Mc (Irid'ium, Wa).

niō'blum (Cl, columbium has clear priority; niobium merely perpetuates one of Rose's errors).

tellū'rium (Wa, It).

*mōly'bdenum** (molybdēnum, Mc, Mr, regarded as settled).

TERMINATIONS IN -IC.

Accent penultimate.

Penultimate vowel in polysyllabic words short, except (1) *u* when not before two consonants; and (2) when penultimate syllable ends in a vowel; in dissyllables long, except before two consonants.

(Ny, Nr, use *-ic* for metals only where there is a contrast with *-ous*; thus avoid aluminum, ammonic, etc.).

acē'tic or *acē'tic*, * (acē'tic, Da, Br, Ny, Wo) (acē'tic, Mc, Nr, Sh, Ws).

chloracē'tic or *chloracē'tic*, * Da, Mc.

absē'nthic, misprint in last report.

mā'lic (mā'lic, Br, Wa).

malō'nic (malō'nic, Br, Wa).

racē'mic or *racē'mic*, * (racē'mic, Da, Br, Ny) (racē'mic, Mc, Nr).

valē'ric or *valē'ric*, * (valē'ric, Da, Br, Ny, Wo).

TERMINATIONS IN -OUS.

Words in *-ous*, following the general rule of the language, take antepenultimate accent, except when two consonants follow the penultimate vowel, in which case the accent is thrown forward.

A clear distinction is thus made in accent as well as in termination between words in *-ic* and *-ous** (accent invariably on penult, O).

acē'tous (exception through usage)* (ă'cētous, Mc, Ws).

hy'drosū'lūrōus, hy'pophō'sphorous, hy'posū'lūrōus, phō'sphorous, sū'lūrōus, tē'lūrōus, mā'nganous, mē'recūrōus (penultimate accent, O, Br, T, Da, Ba).

Fāte, fāt, fār, mēt, mēt, pine, pln, marfne, nōt, mōve, tūbe, tūb, rōle, mȳ, y = I.

' Primary accent; " secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

të/lürous (ü, Wa).

côba'lous, Br, Mr (error in last report).

alumenl'ferous (-mln-, Br).

TERMINATIONS IN -ATE.

Antepenultimate accent (occasionally thrown back).

ă/biëtate (ăbi'-, Sh).

ă/cëtate (ă/cë-, Mr).

antimö'niate (ăntimönäte, Br).

ti'trâte* (ti'-, Pa).

TERMINATIONS IN -ITE.

Accent analogous to -ate terminations.

ă/cëtite (ă/cëtite, Mr, Ws.)

TERMINATIONS IN -IDE AND -ID.

Drop final e in every case, and pronounce -id. Antepenultimate accent. This pronunciation distinguishes clearly between -id and -ite. In German it is difficult and often impossible to distinguish between -id and -it, and in English a confusion often arises between chlorite and chloride, sulphite and sulphide, etc. (See also the note on -ine and -in,* Mc, Do; (-ide, Ba,

Wo, Wy, R); (-ide, Pe).

brömid, etc. (final e, Wr).

hy/drosü/lid, Ny, Wa.

ă/cëtă/mid (acët-, Ny).

TERMINATIONS IN -ANE.

Hydrocarbons belonging to the -ane, -ene, and -ine groups of Hofmann take long vowel.

ĕ/thâne (ĕ/thane, Ny, Wy).

TERMINATIONS IN -ENE.

Antepenultimate accent. Some dissyllables, as benzene, have no distinct accent.

ăcë/tylène (acë't-, Br).

më/taxj/lene, Br.

albü'men* (qu. albumin).

Fâte, fât, fär, mête, mët, pine, pín, marfne, nöte, nôt, möve, tübe, tüb, rüle, mÿ, ÿ = I.

* Primary accent; " secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

TERMINATIONS IN -INE.

Doubly unsaturated compounds in -ine take the normal pronunciation -ine.

prō'pine (-pine, Bu).

TERMINATIONS IN -IN.

All chemical compounds now ending in -in and -ine (except doubly unsaturated compounds, considered above) should end in -in, and this syllable should be pronounced, -in.

The accent is antepenultimate, except when the penultimate vowel is followed by two consonants, in which case the accent is penultimate.

The final e in these words should be dropped as of no important significance.

I. The suggestion of Watts and others to indicate basic substances by -ine and all others (or neutral substances) by -in seems unwise. It makes a difference in spelling, with little or no corresponding difference in pronunciation on the part of most chemists,—a useless and undesirable complication. It demands a very extensive knowledge of the constitution of a great number of compounds with these terminations. It has been partially adopted by many chemists but not consistently by most, and by many it has never been recognized.

II. All continental languages use the pronunciation -in and this is the case with not a few words in English as benzine, marine, while the American public have instinctively taken up this pronunciation in "Pearline, Soapine," etc. In general, however, it seems too foreign to English usage to be adopted by a majority of American chemists. -ine is awkward and would be very foreign to English usage in many words, as chlorine, morphine, nicotine, brucine, etc.

The pronunciation -in is already common in many of these words, as the halogens, anilin, hematin, pepsin, tannin, etc., and at the same time presents a near approach to the continental in, into which it may easily be strengthened if preferred. This reasoning applies equally to the termination -id. * Mc, Ba, Mr, Wy (-ine, T, Do, Pe), (-ine, Wo, Po), (ine, R, Pa).

chrȳ'soidin (oi as in oil) (-ō-I, O).

qui'nin (qui- in this word and all derivatives should be pronounced kl—not kw! — in accordance with its Spanish derivation, Pe).

ā/cētin (ā/cētin, Ws).

cū'marin (ū, Br).

glȳ'cerin (glȳ'cerol preferred), (-ol, Br, Nr).

Fäte, fät, fär, mête, mät, pine, pín, marine, nöte, nöt, möve, tübe, tüb, rüle, mý, ý = I.

* Primary accent; " secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

reso'rcin (-ol, Nr).

vā'nilliu, * (*vāni'llin*, derived from *vanilla*, Cl).

thè'In (*tēin*) (should be dropped, Br, Ht).

ä'kaline (*alkaline*, Ny, Wr, Mc, Du).

cry'stalliu or *cry'stalline* (in, Br, Ny, Mc, Nr) (-ine, Wo).

TERMINATIONS IN -ONE AND -ON.

quīnōne (*qui* = *ki*, Pe; see *quinine*).

ä'cētōne (-et-, Mr.).

TERMINATIONS IN -AL, -IL, -OL, -YL, -YDE, ETC.

-*ol*, final *e* dropped; -*öI*, with two exceptions from usage, R.

be'nzöl (undesirable, should be dropped), Br, Ny, R.

glý'cöl, * (-öI, Wr, Ba).

phé'nöl, * (*phē-*, Ny, Wa).

thý'möl, (*ti*)*.

-*yl*, antepenultimate accent.

ä'cetyl, * (-et-, Mr.).

bö'rë'thyl (*bö'r-*, Br).

cē'rotyl (*cē-*, Ny).

cē'tyl (*cē-*, Ny).

-METER.

Words ending in the termination -*meter* take the normal antepenultimate accent (from usage); except that the words of this class used in the metric system are considered as compound words, and each portion retains its own accent, * (drop the exception, Mr).

äcetyl'meter, *äcétó'meter* (*äcet-*, Ny, Ws).

MISCELLANEOUS.

albü'minoid, * (-en-, Po).

äcetyl'metry (*äcet-*, Ny, Ws).

qua'ntivá'lence (-tl've-, E, Mr).

mô'nová'lent (drop; use univalent, Mr).

ü'nivá'lent.

bi'vá'lent, etc. (In all cases -l'vent, Ns, Mr).

ä'llotrópy, * (*allo'tropy*, Mr, Mb).

äcetyl'ify (*äcet-*, Br, Wo).

alloy' (noun) (*ä'lloy*, Br, E, Ny).

apparå'tus, * 4 to 3, Mc.

Fäte, fät, fär, mête, mët, pine, pïn, marfine, nöte, nöt, möve, tübe, tüb, rüle, mÿ, ÿ = i.

¹ Primary accent; ² secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

apparā'tus (plural) *.

môle'cule ,* (mō'l-, Pa, Sh).

môlēc'ular ,* (mōl-, Br, Nr, Wa).

liter (liter, E, Mr).

ti'träte (ti'-, Br, Mr).

titer (to be avoided) (ti-, Mr).

ä/ntimoneted and other similar terms in -ed (should be dropped, Br).

ä/ikali (ä/ikall -s for caustic; ä/ikali -a for metals, Br).

bärý'ta ,* (bā-, Br).

ölé'fiant (ölé'-f-, Br, Ws).

äqua for'tis (äqua, Mc, Sh).

qualitā'tive and quantitatā'tive (replace by *qualitative* and *quantitative*, deriving the words from the Latin adjectives instead of the nouns, as *rotary* instead of *rotatory*, *agriculturist* instead of *agriculturalist*, O).

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Br R. N. BRACKETT, chemist of the Arkansas Geological Survey.

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Nr Prof. T. H. NORTON, University of Cincinnati.

Ny Prof. W. A. NOYES, Rose Polytechnic Institute.

O Prof. J. M. ORDWAY, Tulane University.

Fäte, fät, fär, mête, mët, pine, pïn, marfne, nöte, nöt, möve, tübe, tüb, rüle, mÿ, y = i.

* Primary accent; " secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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Wo R. O. WOODCOCK, F.C.S., New York.
Wr Prof. A. W. WRIGHT, Yale University.

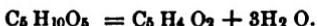
PAPERS READ.

THE OCCURRENCE OF THE PENTAGLUCOSSES. By Prof. W. E. STONE,
LaFayette, Ind.

[ABSTRACT.]

The term "pentaglucose" is applied to a group of sugar-like bodies which closely resemble the ordinary or hexaglucoses except that they are pentatomic, i.e., have the formula $C_5H_{10}O_5$. The known members of this group are *Arabinose* and *Xylose*. They do not occur as such in nature, but are derived by hydrolysis from certain gum-like substances occurring occasionally as abnormal secretions from vegetable tissues but more commonly, as this paper shows, as a constant constituent of lignified tissues from which they may be extracted by dilute alkalies or by the action of acids may be transformed directly into arabinose or xylose as the case may be.

The pentaglucoses are characterized by their yielding, when slowly distilled with rather strong "mineral" acids, large quantities of *furfurol*. This reaction is not given by any of the two glucoses and hence becomes specific for the pentaglucoses. The reaction may therefore be applied not only as a test for the presence of these sugars as such, but also for the original gums from which they are derived, the action being in such cases to change the gum into sugar by hydrolysis and the latter is decomposed to furfural and water probably by this reaction.



In every case, where an attempt has been made to actually isolate the pentatomic sugar from a crude material which gave the furfural reaction, it has been successful. In this way arabinose has been obtained from wheat bran, brewers' grains, the gum of the peach tree, and even the sawdust from cherrywood. So also has xylose been obtained from the wood of different trees, from jute, from straw, etc. In some cases both have been obtained from the same material.

The reaction is therefore specific for the pentaglucoses and the not well defined gum-like substances from which they are derived and may be applied to their recognition in any form of vegetable material.

By its use the presence of these bodies has been proven in quantities varying from one to fifteen per cent in a variety of vegetable matters and food stuffs. In forty samples examined, thirty-two are shown to contain them in quantities which could be quantitatively estimated by the imper-

fect methods used, while no material has failed to give good qualitative reactions for the same.

Since in the ordinary analyses of food stuffs these bodies are classed broadly with the carbohydrates or non-nitrogenous extractive matters from which they differ decidedly in chemical and doubtless also in physiological properties, it is of importance first, to recognize their apparently common occurrence; and, second, to distinguish between them and the true carbohydrates.

THE REDUCTION OF FEHLING'S SOLUTION BY ARABINOSE. By Prof. W. E. STONE, LaFayette, Ind.

[ABSTRACT.]

FROM the fact that arabinose is a pentaglucose ($C_5 H_{10} O_5$) it might be expected that its reducing effect upon Fehling's solution would vary somewhat from that of the true glucoses. Its exact quantitative effect has however never been determined. Solutions of pure arabinose ($(\alpha)_D = 104.1^\circ$) of one, three-fourths, one-half and one-fourth per cent strength were used in connection with the ordinary Fehling's solution. The gravimetric method was followed, the cuprous oxide precipitated from an excess of Fehling's solution by 25cc of arabinose solution being collected on an asbestos filter reduced to metallic copper in a current of hydrogen gas and weighed as such. For all of these solutions one milligram of arabinose precipitated from 1.9 to 2 milligrams of copper, a stronger reducing effect than is shown by any of the true glucoses.

This fact is of importance since the pentaglucoses, as has been shown occur commonly in all sorts of vegetable tissues and in any determination of carbohydrates, by inversion and titration with Fehling's solution, the results would be vitiated by the pentaglucoses (arabinose) causing too high numbers for the true glucoses or carbohydrates.

THE QUANTITATIVE ESTIMATION OF THE PENTAGLUCOSSES IN THE PRESENCE OF OTHER CARBOHYDRATES. By Prof. W. E. STONE, LaFayette, Ind.

[ABSTRACT.]

THE pentaglucoses are widely diffused in vegetable material. Their sugar-like nature causes them to be classified indiscriminately with other carbohydrates, particularly the true glucoses in analytical methods by which the latter are commonly estimated. This classification is erroneous since as already shown their action upon Fehling's solution is different from that of the true glucoses and the substances from which they are derived are widely different from those from which the true glucoses spring.

I have therefore endeavored to develop a method for their quantitative determination in the presence of all other carbohydrates by utilizing their characteristic behavior when distilled with strong acids, viz.: furfurol formation.

The determination as at present carried out has two phases:—

1. The distillation of the finely ground air dry material (2 to 5 grams) with 50cc. of sulfuric acid of 1.254 specific gravity, the loss by distillation being constantly replaced by the addition of water at an equal rate by means of special apparatus. The distillation is continued until the distillate no longer gives the characteristic reaction of furfurol with anilin-acetate.

2. The furfurol containing distillate is made up to a definite volume from which aliquot parts are titrated with a standard solution of phenyl-hydrazin using Fehling's solution as an indicator for an excess of the phenyl-hydrazin solution.

The method, although not yet perfected, is already productive of good results, examples of which are given in the original paper.

DETERMINATION OF THE VOLUMETRIC COMPOSITION OF WATER. By Prof.
EDWARD W. MORLEY, Cleveland, Ohio.

[ABSTRACT.]

GAY-LUSSAC and Humboldt determined the ratio of the volumes in which hydrogen and oxygen unite to produce water. The mean error of a determination was one part in 280; an accuracy admirable then, but insufficient now. Scott has recently made a new determination: the mean error of his twenty-five experiments is about the same as in the earlier determination.

I was at work on the point before Scott's publication. My apparatus for measuring gases is such that measurements have but a small mean error,—as small as $\frac{1}{1000}$ on a volume of 200cc. The operations for determining the ratio desired are as follows:—

1. A weighing globe, *a*, a manobarometer, a store globe, *b*, a mercurial valve, a tube containing copper oxide and a Sprengel pump are connected to a source of hydrogen by a closed valve of fusible metal and exhausted say to $\frac{1}{1000}$. The closed valve is opened by fusion, hydrogen is admitted to *a* and *b* and the remaining apparatus, the opened valve is closed by fusion, the weighing globe is detached, leaving in *b* a store of the same hydrogen for use.

2. The copper oxide is heated and hydrogen admitted by opening the mercurial valve. When a litre has been admitted, the mercurial valve is closed, and the heating continued till the residual hydrogen is but about 10cc.

3. A sample of oxygen is stored in an apparatus like that mentioned in 1.

4. The 10^{cc} of hydrogen are extracted by the Sprengel, and a suitable quantity of oxygen is extracted from the oxygen store. The nitrogen in the 10^{cc} hydrogen is determined.

5. 200^{cc} of hydrogen are now taken from the same store and accurately measured; then 200^{cc} oxygen, then about 200^{cc} more of hydrogen; these are mixed and exploded fractionally; the nitrogen in the residue, and also the carbon dioxide, if produced, are determined.

6. Knowing by 4 the nitrogen in the 400^{cc} of hydrogen taken, we can by difference determine the nitrogen in the oxygen. As other experiments have proved that nitrogen is the only impurity in either gas, carbon dioxide must come, if found, from the oxidation of a film of fat on the walls of the eudiometer. This occurred but twice.

7. Knowing the source of nitrogen and carbon dioxide present in the residue, we can now compute the ratio desired.

Four experiments were abandoned, owing to accidents. Twenty were completed. In one, nitrogen occurred in both gases, the ratio found was 2.00027. In two, nitrogen was present only in the hydrogen, the ratios found were 2.00083, 2.00025. In nine, nitrogen was present only in the oxygen: the minimum value of the ratio found was 2.00005, the maximum was 2.00047 and the mean was 2.00021. In six experiments, there was no measurable impurity in either gas, the minimum value found was 2.00015, the maximum was 2.00088 and the mean was 2.00028. In two experiments, I neglected to wash the eudiometer with aqua regia before the explosion, and carbon dioxide was produced. To the amount of oxygen consumed by the carbon was added 0.4 for oxygen consumed by hydrogen in the lubricant. There was no nitrogen in either oxygen or hydrogen. The values of the ratio found were 2.00020, 2.00029. These are all the experiments which were made.

Weights were assigned to the successive determinations according to the circumstances of the experiment; but the resulting mean is the same as if equal weights were assigned, so that no weights will be stated. The values found are as follows:

1. 2.00027	8. 2.00011	15. 2.00031
2. 2.00033	9. 2.00016	16. 2.00016
3. 2.00025	10. 2.00005	17. 2.00021
4. 2.00019	11. 2.00028	18. 2.00020
5. 2.00012	12. 2.00027	19. 2.00029
6. 2.00047	13. 2.00088	20. 2.00015
7. 2.00024	14. 2.00016	

Mean 2.00028

The mean pressure at which the measurements of the original volumes were made was 71^{cm}. The total volume of hydrogen consumed was 7267.66^{cc}, and that of oxygen was 8633.42^{cc}, both reduced to 0° and 76^{cm}. The mean error of a determination is one part in 26000.

The value $\frac{1}{2}$, determined by Gay-Lussac and Humboldt, therefore requires to be increased by about one part in 9000, if the gases are measured at ordinary temperatures and at nearly the ordinary pressure of the atmosphere.

RATIO OF THE DENSITIES OF OXYGEN AND HYDROGEN. By Prof. EDWARD W. MORLEY, Cleveland, Ohio.

[ABSTRACT.]

USING the apparatus mentioned in my paper on a determination of the volumetric composition of water, I prepare hydrogen in such a way that part of it is weighed and part reserved for a determination of the amount of nitrogen in it; other impurities having been excluded. From the amount of nitrogen found a numerical correction to the density observed is computed. My globes, each of which can be weighed on a balance capable of carrying a kilogramme, contain 21.6, 20.2, 19.9, 9.1 and 9.0 litres. Each has a counterpoise having its external volume adjusted to equality with its own within .05^{cc}. Each has had its compression on exhaustion directly determined; the amounts vary from 1.87^{cc} to 7.89^{cc}. The counterpoise is adjusted for the globe as exhausted. For each globe is made a compensation for compression, consisting of two parts, having, if weighed in a vacuum, exactly the same weight, and differing in volume by the amount of the compression of the globe. Since the counterpoise has the same volume as its globe when exhausted, if a globe is to be weighed full of gas, it is hung on the balance, together with the smaller piece of the compensation, and to the counterpoise is added the other larger piece.

Fifteen experiments have been made, one of which was lost by the breaking of the key of the stopcock of a globe. In ten, hydrogen was prepared by electrolysis of dilute sulphuric acid. In four, hydrogen was obtained in the method proposed by Chirikoff, from palladium. The mean error of the fourteen determinations was one part in 4000, but the number of determinations is to be greatly increased.

Oxygen was prepared from potassium chlorate and weighed like the hydrogen. The value found in each of the three experiments was the same as Regnault's mean value after correction by Crafts and reduction to the latitude and altitude of my baromanometer.

THE ACTION OF ALCOHOL UPON ALDEHYDES. By Dr. SPENCER B. NEWBURY, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

THE writer has further investigated the combination of alcohols and aldehydes (see report of the Cleveland Meeting, August, 1888, p. 126).

In case of unsaturated aldehydes, a further addition of alcohol takes place at the point of unsaturation, forming tri-ethoxy derivatives. The writer was unable to obtain *Tri-ethoxy propane*, $\text{CH}=\text{CH}(\text{OC}_2\text{H}_5)_2-\text{CH}(\text{OC}_2\text{H}_5)_2$, by action of alcohol and glacial acetic acid on acrolein at 100°, as described by Alsberg (Jahresber. 1864, 495), but prepared the product easily by heating acrolein and alcohol together for several days at 50°. The resulting product possesses a fruit-like odor, and boils at 167°-170°.

with considerable decomposition. It was obtained pure by distillation in vacuo.

Tri-ethoxy-butane, $\text{CH}_3\text{—CH}(\text{OC}_2\text{H}_5)\text{—CH}_2\text{—CH}(\text{OC}_2\text{H}_5)_2$, or $\text{CH}_3\text{—CH}_2\text{—CH}(\text{OC}_2\text{H}_5)\text{—CH}(\text{OC}_2\text{H}_5)_2$, was obtained by the action of alcohol on croton aldehyde at 50° , during several days, in presence of a small quantity of zinc chloride. It is a colorless liquid with a pleasant fruit-like odor, which boils with slight decomposition at $188^\circ\text{—}190^\circ$.

[The full text of this paper will appear in the American Chemical Journal.]

SOME THOUGHTS ON ELECTROMOTIVE FORCE. By Prof. C. L. SPEYER,
University of Missouri, Columbia, Mo.

[ABSTRACT.]

THE paper refers to the absence of a satisfactory explanation of the relation between the chemical and electrical energies, and a rough outline is given of the reasons for thinking that there is a connection between the electromotive force developed in a cell and the dissociation of the salt in solution.

Results of measurements with zinc and mercury, in solutions of zinc salts are advanced in support of the dissociation hypothesis, as well as measurements with hydrochloric and nitric acids.

The author proposes to make a large number of measurements with different metals.

ON THE HEATS OF COMBUSTION OF CERTAIN ORGANIC COMPOUNDS. By Prof. W. O. ATWATER and H. B. GIBSON, Wesleyan University, Middletown, Conn.

[ABSTRACT.]

THIS paper gave in brief outline the methods and results of determinations of the heats of combustion of a number of carbohydrates and fats. This is a preliminary report of an investigation undertaken with the aid of a grant from the research fund of the A. A. A. S., supplemented by gifts from other sources.

PRELIMINARY STUDY OF THE PTOMAINES FROM THE CULTURE LIQUIDS OF THE HOG CHOLERA GERM. By E. A. v. SCHWEINITZ, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

THE paper gave a brief sketch of the methods used for isolating the poisons produced by the hog cholera germ, and mentioned some of the

properties of these substances, as well as their physiological action upon guinea pigs. The statement that by vaccination with certain chemical compounds prepared in the chemical laboratory of the Bureau, guinea pigs have been rendered immune from the disease of hog cholera is extremely interesting and promises to be of practical application.

**CHEMICAL EXAMINATION OF OSAGE ORANGE (*MACLURA AURANTIACA*) LEAVES
AND A FEEDING EXPERIMENT IN REARING SILK WORMS.** By E. A. v.
SCHWEINITZ, Ph.D., Department of Agriculture, Washington, D. C.

[ABSTRACT.]

This paper gave a sketch of a feeding experiment with silk worms when the Osage orange leaves were used for food.

Analytical tables of the constituents of Osage orange and mulberry leaves were given and comparisons made between the two classes of food. The extreme richness of these two foods in nutritive substances was pointed out and attention called to the fact that the Osage is very rich in the constituents which the silk worm requires.

ANALYSIS OF BOVISTA PLUMBRA. By Prof. H. A. HUSTON, LaFayette,
Ind.

[ABSTRACT.]

CONFIRMING the results of Prof. F. E. Ladd¹ that American fungi have more nitrogen than the German fungi and showing the ordinary food analysis, the proximate analysis and the amounts of potash and phosphoric acid in the ash.

It is also shown that no sugar or starch or other substance readily yielding reducing sugars is present.

NOTES ON CERTAIN REACTIONS FOR TYROTOXICON. By Prof. HENRY A.
WEBER, Columbus, Ohio.

[ABSTRACT.]

THE physiological test for tyrotoxicon having failed with numerous samples of cheese examined, while at the same time the Prussian blue and carbolic acid tests were obtained, it was found that the last two tests were due to the presence of an organic base and butyric acid respectively.

¹Sixth Annual Report, N. Y. Exp. Sta., p. 465.

THE PROPER STANDARD OF THE ATOMIC WEIGHTS. By Prof. F. P. VENABLE, Chapel Hill, N. C.

[ABSTRACT.]

THE arguments brought forward by Brauner, Ostwald, Meyer and Sennert in the discussion of this subject are summed up in this paper and the conclusion drawn that oxygen = 16 is the natural and most convenient standard. The inaccuracies resulting from the adoption of hydrogen = 1 as the basis are pointed out, as well as the impossibility of ever securing accuracy with such a standard. Incidentally some of the difficulties are mentioned in comparing the results of atomic weight determinations.

ON CHEMISM, AN INQUIRY INTO THE CONDITIONS THAT UNDERLIE CHEMICAL REACTIONS. By Prof. A. E. DOLBEAR, College Hill, Mass.

[ABSTRACT.]

1. In chemical reactions there is an exchange of energy which is measurable in calorics or heat units, which heat units may again be measured in dynamical or mechanical units. The first law of thermo-dynamics asserts this.

2. Again the second law of thermo-dynamics may be expressed thus: that the energy of a chemical compound is proportional to its absolute temperature.

3. As heat is known to be the vibratory motion of atoms and molecules, it follows that at absolute zero there is no vibratory motion and hence no work would need to be done to separate atoms in a molecular compound. That is, it is the temperature of dissociation.

4. Now if for the convenience of a definite idea of an atom we adopt the vortex ring theory which so far has stood the physical, chemical and mathematical investigations, and consider what must be the character of its vibratory motion that constitutes its heat energy, and also suppose it to vibrate at its fundamental rate, there will be four nodes as shown in fig. 1.



FIG. 1.

5. Now a vibrating body diminishes the pressure about it in the medium; in this case the ether, proportional to the square of the amplitude of vibration and hence at the nodes the amplitude is least, and at the midway points, the loops, the pressure will be least as amplitude is greatest.

Suppose then we draw an outline of a field of differing pressure about

such a vibrating atom we shall have something like Fig. 2. This for distinction I will call the chemical field, and if a second atom be within that field it will be subject to a greater pressure on its side, 9, than on the side, 6, and hence will be pushed towards the first atom by the ether pressure, and hence will move, *if free*, to it, but the amplitude of motion being greatest at 6 it will swing round to the point of least displacement, 1, and as there are four such points it follows that four atoms can be attached to the first, thus, Fig. 3; and as each atom so hinged evidently can swing back and forth in some degree, and as each atom has its own nodes and loops indicated in the diagram by the dots, when they swing upwards their nodes will come opposite each other and thus their overlapping fields will conspire with each other to hold them in place and a sort of hollow box with cubic dimensions will be formed. We call this a molecule, which form it will maintain so long as the vibratory rates and amplitude are maintained. If an atom vibrates at some other than its fundamental rate, as is the case generally, then the number of nodes will be higher, but some multiple of the fundamental, 2, 8 or more, a harmonic series. And this will modify in a corresponding way the number and arrangement of the combination.

This can be illustrated in a great variety of ways not needed in this abstract.

The thesis is that the vibratory motions that constitute the heat of the atoms sets up a field of differing pressure in the ether adjacent to the atom, that other atoms in that field will be pushed towards the field of least pressure and as the harmonic motions necessitate nodes in the atoms themselves, there must result a mechanical arrangement of adhering atoms which constitutes what is called chemism, which field will be zero at absolute zero, in conformity with thermo-dynamics.

THE ATOMIC WEIGHT OF OXYGEN. By Prof. W. A. NOYES, Rose Polytechnic Institute, Terre Haute, Ind.

[ABSTRACT.]

At the Cleveland meeting of the Association a somewhat new method for determining the atomic weight of oxygen was described by the author.

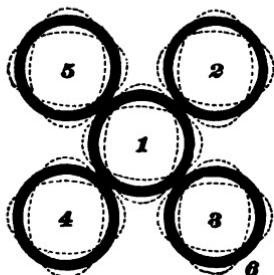


FIG. 3.

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such a vibrating atom we shall have something like Fig. 2. This for distinction I will call the chemical field, and if a second atom be within that field it will be subject to a greater pressure on its side, 9, than on the side, 6, and hence will be pushed towards the first atom by the ether pressure, and hence will move, *if free*, to it, but the amplitude of motion being greatest at 6 it will swing round to the point of least displacement, 1, and as there are four such points it follows that four atoms can be attached to the first, thus, Fig. 3; and as each atom so hinged evidently can swing back and forth in some degree, and as each atom has its own nodes and loops indicated in the diagram by the dots, when they swing upwards their nodes will come opposite each other and thus their overlapping fields will conspire with each other to hold them in place and a sort of hollow box with cubic dimensions will be formed. We call this a molecule, which form it will maintain so long as the vibratory rates and amplitude are maintained. If an atom vibrates at some other than its fundamental rate, as is the case generally, then the number of nodes will be higher, but some multiple of the fundamental, 2, 8 or more, a harmonic series. And this will modify in a corresponding way the number and arrangement of the combination.

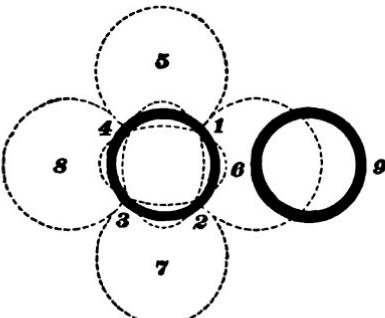


FIG. 2.

Four series of determinations, six in each series, have been completed with the following results:

First series . . .	15.897 ± 0.0032
Second series . . .	15.897 ± 0.0064
Third series . . .	15.899 ± 0.0014
Fourth series . . .	15.898 ± 0.0013
Final mean . . .	$15.896 \pm 0.0017.$

The details of the work are published in full elsewhere.¹

THE UNIT FOR ATOMIC WEIGHTS. By Prof. W. A. NOYES, Rose Polytechnic Institute, Terre Haute, Ind.

[ABSTRACT.]

THE relative densities of oxygen and hydrogen as determined by Regnault and corrected by Crafts² and as determined by Lord Rayleigh,³ and the composition of water as determined by van der Plaats,⁴ Thomsen,⁵ Cooke and Richards,⁶ Lord Rayleigh⁷ and myself,⁸ all indicate that the atomic weight of oxygen, when hydrogen is taken as the unit, is decidedly less than 15.96. If this opinion is generally accepted, the question as to what unit shall be adopted for atomic weights will acquire a new importance. Either we must adhere strictly to the hydrogen standard and change nearly or quite all of our atomic weights to correspond to the new value for oxygen or we must make oxygen our standard and give to it the value 16. The latter course seems the better. If we make O=15.90, the larger atomic weights must be changed by nearly a whole unit. If O be made 16, some of the *most common* atomic weights approximate so closely to whole numbers that the nearest whole number may be used for all ordinary calculations. Even in organic compounds it will rarely be necessary to use the value 1.0068 for hydrogen. The error in calculating the hydrogen when we place H=1, C=12, etc., is almost exactly compensated by the error made in the opposite direction in calculating the results of the analysis. The error in the case of the other elements will very rarely be large enough to be important.

IMPROVED FORMS OF GAS GENERATORS.⁹ By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

NEW devices for the economical and easy generation of gases such as hydrogen, carbon dioxide and sulfuretted hydrogen, in laboratories. [This paper with illustrations will be published in the Amer. Chem. Jour.]

¹ Am. Chem. Jour. **19**, 441. ² Comp. Rend. **106**, 1864. ³ Proc. Roy. Soc., **43**, 356.

⁴ Ann. Chim. Phys. 1886, vii, 529. ⁵ Ber. d. Chem. Ges. **3**, 928. ⁶ Am. Chem. Jour. **10**, 191.

⁷ Proc. Roy. Soc. **45**, 425. ⁸ Am. Chem. Jour. **19**, 441.

⁹ In my papers I have followed the revised spelling.

A CONSTANT AND EASILY REGULATED CHLORIN GENERATOR. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

THE apparatus described provides the lecture-room, or the laboratory, with a chlorin generator as perfectly under control and as constant in its nature as the customary generators of hydrogen, sulfuretted hydrogen or carbon dioxid.

The construction is similar in its general appearance to the familiar forms for hot water filtration.

[This paper with the drawings will be published in the American Chemical Journal.]

DERIVATIVES OF DINITRO-A-NAPHTHOL. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

THE compounds described are a series of salts of dinitro-a-naphthol $C_{10}H_5(NO_2)_2OH$, with various metallic and organic bases. They are of brilliant tints, mostly ranging between yellow and scarlet, and possess powerful tinctorial properties. All are anhydrous and exceedingly insoluble in water.

The action of chlorin on dinitro-a-naphthol has been studied and it has been found possible to replace the nitro group directly by a halogen.

[This paper will be published in the American Chemical Journal.]

A SOLUBLE COMPOUND OF HYDRASTIN WITH MONO-CALCIUM PHOSPHATE. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

THE author obtains by long continued contact of hydrastin with a saturated solution of mono-calcium phosphate, a compound corresponding to the formula $2Ca[H_2PO_4]_2 \cdot 3C_{21}H_{21}NO_8$.

It is readily dissolved in water, but decomposes on heating the solution, and it offers to therapeutics a readily soluble compound of the alkaloid with a substance of recognized tonic value.

[This paper will be published in the American Chemical Journal.]

APPLICATION OF THE POTASSIUM CHLORATE METHOD FOR DETERMINING SULFUR TO THE ANALYSIS OF HORN. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

THIS method of sulfur determination, introduced by the author in the analysis of sulfonates, has been employed in the analysis of natural prod-

ucts containing sulfur and the results compared with those obtained by the use of the method with caustic potash and a current of chlorin. It is found that while both processes give equally accurate results, the potassium chlorate method effects a notable saving of time and heat, avoiding likewise the annoyance of generating chlorin and the tedious operation of neutralizing the caustic alkali.

[This paper will be published in full in the American Chemical Journal.]

**ON A NEW METHOD OF PREPARING BENZENE SULFONIC BROMID AND ON
SOME NEW SALTS OF BENZENE SULFONIC ACID.** By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.]

THE method of Otto for the preparation of sulfonic bromids hitherto used, involving the preparation of sulfonic chlorid, its reduction with zinc dust to sulfuric acid, and the treatment of the latter by bromin, is replaced by the direct action of phosphorus penta-bromid on the sodium salt of a sulfonic acid.

Benzene sulfonic bromid thus obtained, is a colorless, oily liquid, sp. gr. 1.698, distilling with slight decomposition at 140°.

The ammonium, sodium, lithium and potassium salts of benzene sulfonic acid are described. They all yield anhydrous, very soluble crystals.

[This paper will be printed in full in the American Chemical Journal.]

EXPERIMENTS ON THE CHEMICAL CONSTITUTION OF THE SILICATES. By Prof. F. W. CLARKE, Washington, D. C.

[ABSTRACT.]

AN account of experiments performed in the laboratory of the U. S. Geological Survey in the line of the fractional decomposition of certain magnesian silicates.

THE ACTION OF SODIUM ON ACETONE AND THE CONSTITUTION OF ALIPHATIC KETONES. By Prof. PAUL C. FREER, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

THE substance known as aceto-acetic ether, first prepared by Gunther, has had two formulæ assigned to it: (1) $\text{CH}_3\text{---CO---CH}_2\text{---COOC}_2\text{H}_5$ and

(2) $\text{CH}_3\text{---COH=CH---COOC}_2\text{H}_5$. It gives a sodium derivative with sodium or sodium ethylate, which is either (1a) $\text{CH}_3\text{---CO---CHNa---COOC}_2\text{H}_5$, or (2a) $\text{CH}_3\text{CONa = CH --- COOC}_2\text{H}_5$. Upon the action of methyl or ethyl iodide it gives alkylated derivatives in which the radical is attached to carbon $\text{CH --- CO --- CHCH}_3 \text{ --- COOC}_2\text{H}_5$ and $\text{CH}_3 \text{ --- CO --- CHC}_2\text{H}_5 \text{ --- COOC}_2\text{H}_5$, while with acetyl chloride or acetic anhydride it gives an acetyl derivative in which that group is similarly placed. These considerations have led to the ketone formulæ (1 and 1a) given above. Another argument in favor of this constitution is that the ether is easily reduced by sodium amalgam, while similar unsaturated compounds such as 2 or 2a, are not. In favor of formula 2 we have the fact that the substance does not react with two molecules of benzaldehyde as acetone, $\text{CH}_3\text{---CO---CH}_3$, does; that it can add itself to unsaturated esters, such as cinnamic ester $\text{C}_6\text{H}_5\text{---CH=CHCOOC}_2\text{H}_5$, just as does sodium ethylate NaOC_2H_5 , which would lead us to expect the formula $\text{NaO---C---CH}_3\text{ --- CONa = CH --- COOC}_2\text{H}_5$. The formation of alkylsubstituted aceto-acetic ethers in which the radical is attached to carbon can be explained by the assumption of an addition of methyl or ethyl iodide to the sodium compound and a subsequent separation of sodium iodide. The consideration of the constitution of aceto-acetic ether involves that of other aliphatic ketones, as well as that of their sodium derivatives, and is therefore of great theoretical interest. Acetone, the simplest of all ketones, reacts violently with sodium in the same manner as aceto-acetic ether. By the action of sodium on acetone one atom of hydrogen is replaced by sodium: $2\text{CH}_3\text{---CO---CH}_3 + 2\text{Na} = 2\text{CH}_3\text{---CONa=CH}_2 + \text{H}_2$. This sodium compound is extremely unstable, rapidly turning red on exposure to the atmosphere and yielding high boiling products such as phoron. The sodium compound is very reactive, owing to the absence of negative groups in acetone. On treatment with chlorcarboxylic ether, $\text{ClCOOC}_2\text{H}_5$, sodium acetonate separates NaCl and gives a neutral oil boiling at 129° , which an analysis and vapor density determination showed to be an isomer of aceto-acetic ether, $\text{CH}_3\text{---CONa=CH}_2 + \text{ClCOOC}_2\text{H}_5 = \text{CH}_3\text{---CO---COOC}_2\text{H}_5 + \text{NaCl}$. The formation of this body



proves that sodium in acetone is connected with oxygen $\text{CH}_3\text{---CONa=CH}_2$, and not with carbon as has been assumed in the case of aceto-acetic ether or similar ketones. Unless we wish to abandon our ketone formula for acetone we must believe that acetone has the formula $\text{CH}_3\text{---CO---CH}_3$, while its sodium compound is $\text{CH}_3\text{---CONa=CH}_2$. Similar experiments by Michael with aceto-acetic ether have shown the same to be true there, so that we can assume that the free ketones have the formula XC---CO---CX , while the sodium derivatives are XC---CONa=CX . This is to be expected when the positive nature of sodium is considered, and when we also take into account its close proximity to oxygen in these bodies. It is probable that in all organic sodium compounds containing oxygen, the sodium, where possible, is attached not to carbon but to oxygen.

ON THE MINERALS CONSTITUTING A METEORITE FOUND IN KIOWA CO., KAN.
By Prof. E. H. S. BAILEY, Lawrence, Kansas.

[ABSTRACT.]

THE author gives a brief history of this remarkable group of meteorites and especially describes one weighing 218 pounds. The several minerals, Olivine, Chromite, Troilite and the iron-nickel alloy are analyzed, and their composition discussed. This pallasite is peculiar in furnishing such fine crystals of olivine and chromite. These are in quite deep cavities, where they have been protected from the action of the weather.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF
AGRICULTURE. MUCILAGINOUS, NITROGENOUS AND DYSMORPHOUS CARBOHYDRATE BODIES IN THE SORGHUM PLANT. By Prof. HARVEY W. WILEY and WALTER MAXWELL, Washington, D. C.

[ABSTRACT.]

THE mucilaginous and dysmorphic bodies in sorghum molasses were precipitated and separated, according to their different solubilities, in water, dilute acid, dilute alkali and cuprammonium.

It was found that these bodies are composed of nitrogenous and non-nitrogenous matters, and were, for the most part, mucilages and carbohydrates.

It has further been observed that each class of these bodies is represented by several modifications which are distinguished mainly by their differing degrees of solubility, *i. e.*, that there are mucilaginous and carbohydrate bodies which are distinguished from each other by the fact that certain are soluble in water, others in dilute acids, dilute alkalies and cuprammonium respectively, which confirms the physiological supposition upon which the study of these amorphous bodies was based, *viz.*, that the whole of them were probably not soluble in water.

Not only have mucilages and carbohydrates been observed during the course of these studies in the sorghum molasses, but other bodies have been found of a nitrogenous nature. A general view of the organic series of bodies (other than sugars) in those molasses may be gained by means of consecutive fractional precipitations with the following reagents:— By addition of lead acetate to an aqueous solution of the molasses, the chief part of the nitrogenous matters (mucilages and albuminoids), with organic acids, etc., are thrown out. Upon removing the excess of lead from the filtrate, the amorphous carbohydrates are removable with strong alcohol; And finally, after removing by evaporation the alcohol from the filtrate and taking up the residue in water and purifying with bone-black by adding phosphotungstic acid an alkaloidal principle may be found. Such a body has been obtained by a different method and in a crystallized form as a double salt of chloride of platinum, of which a specific study has not yet been made.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. ON THE METHOD OF ESTIMATION OF THE FATTY BODIES IN VEGETABLE ORGANISMS AND THE BEHAVIOR OF THE GLYCERIDES AND LECITHINES DURING GERMINATION. By WALTER MAXWELL, Washington, D. C. Presented by H. W. WILEY.

[ABSTRACT.]

THE effect of the action of ether upon the extraction of the glycerides and substituted glycerides was studied and as a result it was concluded that a longer extraction than fifteen hours with pure ether was not necessary. Any additional extract, which might come from prolonging the time beyond fifteen hours, was doubtless due to the action of the ether upon other bodies present.

These investigations have been conducted with the purpose of acquiring some further data showing the comparative proportions of matters which become separated from vegetable organisms by extracting with pure ether in variable durations of time. It has further been attempted to determine whether the whole of the substituted glycerides, or lecithines, do become separated by direct extraction with ether only. The studies have also been extended to an observation of the behavior of the glycerides and lecithines during germination.

During the process of germination, which process has been observed during several stages of the plantlet's early growth, it appears that the ferments or solvents present in the mother seed, and which are the operative agents in incipient growth, do act differently upon the glycerides and the substituted glycerides; that whilst the former become immediately broken up to afford the earliest provisions of nutriment to the germ, the lecithines are not acted upon in the same degree, but appear on the other hand to resist, and it may be totally, the action of the seed solvents.

As a final physiological indication to be deduced from the results of the investigations treated of it, does appear that lecithines are formed from the mineral phosphorus present in the mother seed, and that the lecithines present in the original seed may not become decomposed under the action of the ferments during germination, but those bodies may pass over into the young plantlet without any change in their constitution. This latter consideration will be pursued in further investigations, and extended in order to embrace the greater question as to whether the lecithines are formed in the organisms of animals or taken up directly from vegetable bodies.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. PINE TREE SUGAR (*PINUS LAMBERTIANA*). By Prof. HARVEY W. WILEY, Washington, D. C.

[ABSTRACT.]

THE samples of crude sugar were obtained in California where the *Pinus lambertiana* grows in its greatest luxuriance. The method of pur-

fying the crude sugar is given and the properties of the purified sugar are stated. Reference is also made to a paper by Berthelot, published in 1856, in which he described some pinite obtained from the same source in California. It is shown that the specific rotatory power and the formula assigned by Berthelot to the pinite are incorrect.

Reference is also made to a paper by Maquenne, in which he describes the properties of some pine tree sugar which he describes as coming from Nebraska. It is shown that Maquenne was mistaken in regard to the origin of the sugar, since no trees of this kind grow in that state. It is shown also that Maquenne's sugar was identical with that examined by me and hence the name which he gives to it, viz., *Beta pinite*, to distinguish it from the pinite described by Berthelot, is a misnomer. There is only one kind of sugar, viz., pinite, and hence the introduction of the term *Beta pinite* into literature is likely to lead to confusion.

The results of the direct oxidation of the pinite, by means of nitric acid, are also given, it yielding, under this treatment, first oxalic acid and afterward a highly colored acid, which according to some observations of Maquenne, is probably rhodizonic acid.

The behavior of the sugar with the usual reagents is also described. It is shown that the chemist has, in this exudation of the *Pinus lambertiana*, a chemical body of the most remarkable and interesting properties. It is evident that the study of these properties has only been well commenced, and with the large quantities of the material which are now at my disposal, I hope, at a subsequent time, to add something to our knowledge concerning it.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT
OF AGRICULTURE. PINE TREE HONEY-DEW AND PINE TREE HONEY.
By Prof. HARVEY W. WILEY, Washington, D. C.

[ABSTRACT.]

THE paper contains a description of the saccharine exudation from the pine leaves of the forests near Amherst, Virginia.

The analysis of this body showed that it contains a substance of a dextrogyrous nature having a specific rotatory power of about 105. This corresponds very nearly to the specific rotatory power of arabinose, but there was not enough of the material to identify the body as arabinose. The examination of the honey collected by the bees during the winter from these forests did not reveal, however, the presence of this right handed body, the honey having an apparently normal constitution.

The honey was apparently genuine being certified by Mr. Evans, to his personal knowledge, as having been made from the exudation of the pine tree.

Reference is made to descriptions of others of honeys which have been

derived from pine tree exudations showing a normal right handed polarization.

It is shown without doubt that the honey-like exudation of the pine tree differs in a marked degree from the exudation of ordinary plants in being right handed and containing bodies not sucrose nor invert sugar with a specific rotatory power of above 100.

It appears further that, according to the observations of some authors, honey made from the exudation of pines is naturally right handed, but these observations were not confirmed by the single sample at my disposal.

**CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT
OF AGRICULTURE. ON THE NITROGENOUS BASES PRESENT IN CATTLE
FOOD PREPARED FROM COTTONSEED MEAL. BY WALTER MAXWELL,
Washington, D. C. Presented by H. W. WILEY.**

[ABSTRACT.]

THE nitrogenous bases, cholin and betain, have been found to be contained in the cattle foods prepared from the cottonseed. The history of the discovery of these bodies in the cottonseed is given. The investigation was based upon the fact that young calves fed on cottonseed have often been poisoned by its use.

Böhm states that having examined the cattle food which had poisoned some calves, he found it to contain only cholin.

The experiments establishing the toxic principles of cholin are described. A description of the method of carrying on the investigation is also given. Preparations of the different materials were obtained and will be shown.

The results of these investigations have again shown the presence of the nitrogenous bases found in the cottonseed cattle foods by Ritthausen and Böhm. It has been further indicated that betain, which is an oxidation product of cholin, and under a different organic classification to the latter and has been accepted as a non-toxical body, is contained in a large proportion; and that cholin, whose toxic character has been shown by the data established by Gaehtgens, is found in the cottonseed foods in comparatively very small amounts.

From a dietary standpoint, the investigations do not indicate that any inimical consequences, which may occur from the feeding of cattle with those foods, are traceable to the nitrogenous bases which are present in the cottonseed, providing it be accepted that the amido body, betain, exercises no toxic effect; neither does it appear, in the light of the present knowledge of the constituents of the cottonseed foods, that any evil results should attend the feeding of cattle with those foods if served with the same moderation and in the same quantities as other similarly nutritive food matters which form the common diet of animals.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. KNORR'S EXTRACTION APPARATUS. By Prof. HARVEY W. WILEY, Washington, D. C.

[ABSTRACT.]

THE apparatus described is designed for the purpose of removing entirely from extraction apparatus of every description the use of corks and ground-glass stoppers.

The disadvantage of using cork stoppers or rubber stoppers of any kind is well-known to all, and these stoppers have first to be carefully extracted in the solvents which are to be used and their tendency after this treatment to become dry, hard and cracked open, has entailed great loss of material used as a solvent. Ground-glass stoppers have always to be used in the same order so that in case a piece of the apparatus is broken it cannot be replaced by another piece of apparatus without the trouble of again grinding the stopper until it is tight. These difficulties are entirely removed by the apparatus devised by Mr. Knorr who makes the condenser and hood of the apparatus one piece of glass. The tube containing the material to be extracted, may be either of the siphon variety or an ordinary tube and it is held within the hood by a convenient support. The chief novelty of this apparatus consists in the flask which contains the solvent. This flask is softened at the shoulder and the neck is pushed down into the body of the flask making a circular impression into which the lower edge of the hood of the extraction apparatus fits. The flask is held in position by a rubber band strung over two knobs blown on the sides of the hood. When the flask is in place the depression is filled with mercury making a perfectly tight joint. Any solvent which may accumulate between the sides of the hood and the neck of the flask is removed by a small siphon. A number of these extraction apparatus is placed together and the shelf below them is made of cast iron drained toward the centre, while the water used for condensation is removed by an arrangement which prevents any mercury which is spilled upon the shelf from being lost.

This apparatus has been in use in our laboratory for about a year and has given most perfect satisfaction. This apparatus is illustrated by diagrams.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. SOME NEW FORMS OF APPARATUS FOR DRYING SUBSTANCES IN AN ATMOSPHERE OF HYDROGEN. By Prof. HARVEY W. WILEY, Washington, D. C.

[ABSTRACT.]

THE object of the first piece of apparatus shown is to secure an absolute passage of a current of hydrogen over the substance to be dried, and at the same time permit economy in the use of the dried hydrogen gas.

The perfectly pure and dried hydrogen is conveyed into the apparatus, which is shown in the figure, passes over the substance which is to be dried and then into a bulb apparatus containing strong sulphuric acid. Passing through the sulphuric acid any moisture, which it has taken up, is removed and the dried gas passes into the next tube. The apparatus which has been used will hold eight samples, all of which will be dried by one current of gas. Of course there is no objection to making the apparatus larger so as to hold an indefinite number of samples. The tube containing the substance does not come in contact with the steam, and at the end of the operation is conveniently removed, dried and weighed.

Attempts have also been made to check the weights of the moisture by the increase in the weight of sulphuric acid, but these attempts have not proved highly successful.

The apparatus has been in use for about one year and has given entire satisfaction. The apparatus is illustrated by diagrams.

The second form of apparatus shown is designed for the purpose of drying substances in open glass dishes, etc., in an atmosphere of hydrogen.

The apparatus consists of a heavy cast iron plate, ground smooth, on which rests an ordinary bell-jar, such as is used with air pumps. Passing through the iron plate, is a small brass tube which is wound into a coil inside of the bell-jar; this coil also extending as a floor above the iron plate at a sufficient distance to allow the introduction of a vessel containing strong sulphuric acid. The apparatus, when ready for use, is filled with perfectly dry hydrogen, a slow current of which is made to pass constantly into the bell-jar from the tube. The excess of hydrogen passes out between the edge of the bell-jar and the iron plate. Steam is introduced in the coil at any required pressure, the pressure being regulated by stop-cocks at the exit and entrance of the coil. By this arrangement, the temperature inside the coil can be controlled and made to register degree up to as high as 102° or 108° .

The apparatus has been in use for some time and has given entire satisfaction. It is illustrated by diagrams.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF
AGRICULTURE. APPARATUS FOR RECOVERING HIGHLY VOLATILE SOLVENTS.
By Prof. HARVEY W. WILEY, Washington, D. C.

[ABSTRACT.]

The apparatus described is designed for the purpose of recovering a volatile solvent, while at the same time permitting the material in solution to be deposited in an open dish so as to be removed and studied as desired.

The apparatus consists of a bell-jar, or bottle, with the bottom cut off, resting in a metal pan, preferably of iron, containing mercury. This pan

is heated by a steam bath from below. The dish containing the solvent which is to be recovered is placed upon the surface of the mercury, the bell-jar placed in position making a perfectly tight joint. Additional quantities of the solvent can be introduced through a funnel as the liquid in the dish disappears. The vapors of the solvent are conducted into a condenser and collected in a flask, which, in the case of very volatile solvents, such as ether, is kept surrounded with ice.

By the use of this apparatus large quantities of ether, alcohol, chloroform, etc., which are ordinarily wasted, can be saved, while the extract which is left in the dish is readily examined.

The apparatus is illustrated by diagram.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. APPARATUS FOR EVAPORATING IN VACUO. By GUILFORD L. SPENCER, Washington, D. C.

[ABSTRACT.]

THE object of this apparatus is to secure the evaporation of small quantities of liquid in vacuo and at a low temperature. It consists of a strong double copper bath for the purpose of carrying steam. The inside of the inner bath is plated with gold. It presents on its upper surface a smooth broad edge, on which a convenient packing can be placed. On this packing is placed a bell-jar with a very broad ground glass edge. The whole is connected with a small water pump, and a thermometer hanging inside to register the temperature at which the liquid is maintained. By this apparatus it is easy to maintain a vacuum of from 26 to 27 inches of mercury and to secure the evaporation of the liquid at a very low temperature, so that the bodies which it contains in solution may be recovered unchanged. The vessel in which the liquids are placed being coated with gold, no contamination of the material is to be feared.

The apparatus is furnished with a strong safety flask, with two sets of valves, which prevent the inrush of air into the apparatus in case any accident should happen to the pump.

The apparatus is illustrated by diagrams.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. APPARATUS FOR DETERMINING SOLUBILITIES. By AUGUSTUS E. KNORR, Washington, D. C. Presented by H. W. WILEY.

[ABSTRACT.]

THE object of this apparatus is to obtain the maximum of saturation of any given solvent at a given temperature. The apparatus is conveniently constructed, compact and easy of manipulation. The saturated liquids are filtered at the temperature at which the saturation takes place so that

no solid matter, except that which is in solution, can be determined in the filtrate.

A method of stirring the substance so as to promote the solution is also provided. The apparatus is fully illustrated by means of diagrams.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. ON THE ALKALOIDAL PRINCIPLES PRESENT IN THE SKED BERRIES OF CALYCANTHUS GLAUCUS. By Prof. HARVEY W. WILEY and H. E. L. HORTON, Washington, D. C.

[ABSTRACT.]

THE paper is a continuation of the subject presented at the chemical section of the Toronto Meeting. Further studies of the alkaloidal principles have been made and a method devised for their partial separation.

There appear to be three alkaloidal principles, but only one of them, viz., calycanthine, has been obtained in a state of complete purity. The separation of the others has been based upon the different solubilities of their sulphates in alcohol and of the alkaloids in dilute solutions of sodium hydrate.

The various salts of the calycanthine alkaloid have been prepared and their properties studied.

Crystallographic studies have also been made of the distinct crystalline forms.

The specific rotatory power of the alkaloid and its salts has also been determined, and it is found that for the alkaloid this specific rotatory power is the highest of any known substance, being approximately 650 for the sodium ray in a 1 per cent solution. The rotation is to the right.

Attempts have also been made to study the constitution of the body from its oxidation products and interesting relations have thus been disclosed. The study of the body has proved to be much more complicated than was at first anticipated and the present paper simply gives the results of the progress which has been made in extending our knowledge of the constitution of this body in the limited time which has been placed at our disposal since the last meeting.

The latest methods for the purification and preparation of the substance are also given.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. ON A CONSTANT RATIO BETWEEN A REDUCING SUGAR AND THE AMOUNT OF COPPER SET FREE, DETERMINED GRAVIMETRICALLY. By J. L. FUELLING, Washington, D. C. Presented by H. W. WILEY.

[ABSTRACT.]

THIS paper discusses the ratio of reducing copper and the quantities of dextrose and invert sugar which may be present in the reducing solutions.

Reference is made to the work of Alliin and others in the variations in the constant expressing the ratio of the reducing copper and the amount of reducing sugar employed, and it was attempted to determine experimentally whether or not it was possible to obtain an invariable constant for sugar solutions of varying strength.

A normal 1 per cent solution of pure dextrose was used for the establishment of a basis of observations. The constant which was afforded by this strength of sugar solution is accurately determined, the copper being precipitated electrically.

Stronger and weaker solutions were then taken and the amount of copper solution employed increased proportionately to the strength of the sugar solution. It was found by this treatment that the constant remained invariable, being different, of course, for dextrose and invert sugar, but invariable for each one, providing the quantity of copper solution taken was kept proportional to the amount of reducing sugar present. This being done it was found that the factor once determined was good for all solutions.

It is only necessary, in the case of unknown solutions, to make a preliminary determination to determine approximately the quantity of reducing sugar present. The exact determination can then be made by using the proper amount of copper solution and multiplying by the factor obtained.

The analytical data and the factors for each of the different sugars are given.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF AGRICULTURE. ON THE PRESERVATION OF SUGAR SOLUTIONS AND INFLUENCE OF BASIC AND NORMAL LEAD ACETATE ON ANALYSIS THEREOF.
By HUBERT EDSON, Washington, D. C. Presented by H. W. WILEY.

[ABSTRACT.]

THIS paper gives a history of the literature devoted to the influence which basic lead acetate has upon the polarization of sugars. Experiments were also made to determine whether or not the use of basic lead acetate had any permanent effect upon the amount of reducing sugar present, and if so to select some substance which would be free from objection in this particular. Four sets of analyses were made to determine this point.

In the first set basic lead acetate was used, and after clarification the lead precipitated in the usual way and the reducing sugar estimated.

In the second analysis basic lead acetate was used to which afterward acetic acid was added, until the solution was acid, after which the lead was precipitated and the reducing sugar estimated in the usual manner.

In the third set of experiments, normal lead acetate was used and, af-

ter clarifying, the lead precipitated in the usual manner and the reducing sugar determined.

In the fourth set of experiments the reducing sugar was determined in solution without the addition of lead at all. The results obtained by this latter method were taken as a standard. Compared with those it was found that the results obtained by the use of the third method, viz., by the use of normal lead acetate, were found to be strictly comparable. The results obtained by the use of basic lead acetate with the subsequent addition of acetic acid were found to vary to a considerable extent from those of the fourth method. The results obtained by the first method, with the use of basic lead acetate, were found to vary enormously from the standard method, this variation amounting sometimes to as much as 20 per cent.

The analytical data on which these observations are based are given. It is concluded from them that it is not safe to use basic lead acetate, even with acetic acid, in solutions in which the reducing sugar is to be determined.

It is further found that the normal acetate of lead will preserve the solution from fermentation as well as the basic acetate and hence for both purposes the use of the normal lead acetate is recommended.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF
AGRICULTURE. STUDY OF FEHLING SOLUTION IN ESTIMATION OF SUG-
ARS. By H. E. HORTON, Washington, D. C. Presented by H. W.
WILEY.

[ABSTRACT.]

THIS paper is the first part of a series on the estimation of sugars using Fehling solution.

After stating the necessity for sugar work to be done using one Fehling solution, a list of the many solutions is given and, when possible, their values.

The work begins with preparation and purification of dextrose used in the determination and then an attempt is made to obtain Soxhlet's figures, which figures are verified.

Dextrose is next titrated against different Fehling solutions and different results obtained, and at this point the influence of different quantities of alkali is studied. The preparing the alkali Rochelle solution fresh before every determination is shown to be unnecessary.

The study of what Fehling solution to use in gravimetric sugar determinations is begun in this paper, but is not finished. The use of solutions containing 120 grams alkali seems to be undesirable and work using 52 grams alkali, the amount used by Soxhlet in the solution for volumetric work, is now in progress and will be compared with the work using 120 grams.

Work is in progress on galactose, arabinose, levulose.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT
OF AGRICULTURE. THE ESTIMATION OF THEINE IN TEAS. By GUILFORD L. SPENCER, Washington, D. C.

[ABSTRACT.]

THE estimation of theine has received more attention from analysts than its value, from a practical point of view, with reference to the quality of teas, seems to warrant. The evidence of numerous investigators indicates that the percentage of theine is only very generally speaking, in a direct ratio with the price and quality of the tea. A very high-priced tea may have a low theine content and vice versa.

The methods usually employed require extraction in a percolator, concentration of the percolate in the presence of excess of calcined magnesia or calcium hydrate and subsequent percolation with chloroform or ether. These methods usually produce a theine contaminated with coloring matter and other impurities. After experiments with a number of methods, the following was adopted:—

Three grains of the finely powdered tea are transferred to a 300^{cc} flask and boiled gently thirty minutes with nearly this volume of water, a fragment of tallow being employed to prevent frothing. After cooling add subacetate of lead in slight excess, complete the volume, shake and filter, rejecting the precipitate unwashed. Pass H₂S through 100^{cc} of the filtrate, in a sugar flask, i. e., a flask graduated to 100 to 110^{cc}, heat to the boiling point to expel excess of H₂S, cool, complete the volume to 110^{cc} and filter. Extract 55% of the filtrate seven times with chloroform in a separatory funnel; distil off the chloroform, dry the theine below 79° C. and weigh. The resulting product is very pure and contains one molecule of water of crystallization.

The volume of the powdered tea and lead precipitate introduces a slight error which, even in excessive cases, is less than .02 or .03 per cent. If too large an excess of lead has been employed, a correction must be made for the volume of the lead sulphide.

THE NEW CHEMICAL LABORATORY OF CORNELL UNIVERSITY. By Dr.
SPENCER B. NEWBURY, Cornell Univ., Ithaca, N. Y.

CONSTITUTION OF BENZOQUINONE. By Prof. J. U. NEFF, Clark University,
Worcester, Mass.

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ADDRESS

BY

JAMES E. DENTON,

VICE PRESIDENT, SECTION D.

*HISTORY OF ATTEMPTS TO DETERMINE THE RELATIVE
VALUE OF LUBRICANTS BY MECHANICAL TESTS.*

THE measurement of frictional resistance, or friction of rubbing surfaces, is a field in which experimenters have labored from as early a date as 1700. For about a century subsequent to this date, investigation was confined to the friction between solid bodies and therefore the action of unguents or lubricants between the rubbing surfaces appears not to have been studied until 1800.

The variety of practical lubricants at this date was small. Lard, olive oil and black lead were used universally. Experimenters appear to have sought the average value of the coëfficient of friction, with all or any of these lubricants, rather than the determination of the difference between their respective abilities as friction reducing elements. The fact that a fluid or mobile oil was more difficult to be retained between two rubbing surfaces than was a thick or viscous lubricant was, however, a distinction always recognized. Rennie, in 1829, experimenting on the friction of axles with one thousand pounds load, noticed that the coëfficient of friction was less than for lighter loads. Hence he concludes that the less the pressure the more fluid should be the unguent. Thus we have the idea of durability and friction reducing power combined to serve as a basis of distinction between the practical value of even the few lubricants of this early age.

General Morin, experimenting in 1833 with the deliberate intention of improving upon the work of all previous investigators

and undoubtedly broadly informed regarding any practical demand for distinctions of value between lubricants, apparently does not attempt to draw from his mechanical tests any conclusions regarding the value of one unguent with reference to another.

Morin's measurements of friction of lubricated journals did not extend to light pressures. They apply only to the conditions of general shafting and engine work.

He often refers to the circumstances which bring about the expulsion of lubricants from between rubbing surfaces.

He also clearly understood that there was a frictional resistance due solely to the viscosity¹ of the oil and that, therefore, for very light pressures, the laws which he enunciated did not prevail. There can be little doubt that the effect of elevation of temperature in reducing the viscosity, and thereby the resistance due to friction was understood in Morin's time. Also the increase of the coefficient of friction at very slow speeds is a fact which is so clearly shown by a moving surface which gradually stops, that it could not escape the notice of any one using any sort of dynamometer to measure friction. In enunciating his celebrated laws of friction, which maintain that the coefficient of friction² is independent of speed, pressure and surface, it is not to be supposed that he failed to learn that they were not exact for light pressures, but rather that he did not see any practical demand for measurements under conditions different from those to which he applied his dynamometers; namely, to ordinary shaft journals *without special preparation of the rubbing surfaces; and without resorting to artificial methods of supplying the oil.* In confining his experiments to practical conditions, such as still apply to the majority of machinery in use everywhere, and ignoring irregularities of data, evidently within the unavoidable variations of practical conditions of service, Morin, through the declaration of his simple laws, supplied the engineering profession with a greater proportion of all the knowledge that is useful regarding the friction of general machinery than has any other one experimenter. Later experimenters have with few exceptions devoted themselves exclusively to the measurement of resistance practically due to viscosity alone. They have eliminated the resistance to which Morin confined his measurements, namely,

¹ [Art. 257] Morin's Mechanics by Bennet.

² Morin distinctly states that the term friction is used by him to mean resistance between lubricated surfaces which is not created by the viscosity of the oil.

the friction due to such contact of the rubbing surfaces as prevails with a very thin film of lubricant between comparatively rough surfaces. Thus Hirn in 1854 balanced a brass on the top of a large journal; so that the friction could be measured by the load necessary to maintain equilibrium. The lower segment of the journal was *immersed* in a bath of oil to be tested. This is the first artificial condition tending to eliminate the friction due to metallic contact. A second such condition was the nursing of the journal by long preliminary running to a degree of smoothness inconsistent with the ordinary roughness of the bearings.

The pressures were quite light, and the results discover that a considerable variation of friction is caused by a variable range of temperature, because the friction was mainly that due to viscosity, and the latter property decreased with increase of temperature.

Also the coefficient of friction was found to be not independent of the pressure, or area of surfaces; another evidence of the fact that the resistance under measurement was not the friction of metallic contact, but that due to viscosity alone. Hirn's apparatus was the first to control the temperature by the circulation of water through cored passages in the brass; and he was the first experimenter who determined friction over the wide range of temperature from 0° to 500° Fahr.

Many able experimenters have worked in the same field since his time. Prominent among them are Napier, Conti, Thurston, Woodbury, Waite, Wilson, Pullin, Kimball, Wellington, Tower, Reynolds, Goodman and workers at the laboratories of the Eastern railway of France, at various other English and American railways, and at the U. S. Navy Yard, Brooklyn. All have contributed some original matter to the subject, either in their apparatus or by investigating special conditions of lubrication.

In every case, however, the supply of oil has been unrestricted, or the rubbing surfaces have been artificially smooth, or both these conditions have simultaneously existed.

The results with one exception have always consisted solely of the measurement of the coefficient of friction. They have generally been useful in exhibiting some interesting variation of friction due to changes of pressure, speed, or surface of bearings, but are consistent only with the view that the resistance measured was largely that due to viscosity and not the friction of metallic contact.

As a natural result of these investigations, measurements of the coefficient of friction have come to be regarded as essential to a knowledge of the character of lubricants, and apparatus for this measurement, or "*oil testing machines*," are now to be found in operation in the hands of experts employed by various large consumers of lubricants. The possibilities of using such apparatus for determinations of differences of lubricating value of oils and greases for external bearings is the special subject to which I invite attention.

The advent of petroleum products as lubricants has afforded an almost infinite variety of combinations and qualities of lubricants. Instead of choosing his lubricant from among the few simple materials of Morin's time, the consumer must now decide among a great variety of samples, every possible mixture being represented to him as possessing some peculiarity of lubricating value. Moreover, he is asked to believe, on the one hand, that an oil nearly as thin as water will lubricate nothing but a cotton spindle, and, on the other, that sand is beneficial to a railroad box. He is told that only a particular expensive cylinder oil can make his engine run safely, and, on the other hand, that the best results will follow from using no oil at all.

Various measurements of an oil can be made by the chemist. Such elements as specific gravity, evaporative qualities, tendency to spontaneous combustion, viscosity, proportion of animal ingredients, combustion residue, etc., can be readily and definitely determined. But these while serving to fix the identity of the lubricant for purposes of duplication, for example, are all of no weight in determining the ability to lubricate, compared to the evidence of some mechanical test to which, it is claimed, the lubricant has been subjected by practical service, or which, it is supposed, may be available in an oil-testing machine.

To fix the ideas regarding the capabilities of oil-testing machines, consider the following facts:—

Case 1. The principal expense of power in a cotton mill is the friction of the machinery. The pressure on all the bearings is comparatively light; there is, therefore, no sensible wear of the metallic parts of the bearings. The shafting is provided with oil cups, which reduces the waste of oil to a minimum, and the drippings from bearings are filtered for repeated use. The spindles, which consume the bulk of the power, run in cups or baths of oil.

The driving resistance is, therefore, purely that due to the viscosity of the oil. A number of oils are offered for lubrication of the spindles. They are all equally satisfactory as regards volatility, fluidity, flashing point, etc. What will a mechanical test, on an oil-testing machine, tell us regarding the relative value of the oils? *Answer.* It can show that there are mixtures of animal and mineral oils, which will offer but half the frictional resistance of lard or sperm oils, which formerly were exclusively used. Any form of oil tester, such as the "Woodbury," "Thurston," "Ashcroft," "Pullin," or "Tower" can be used to show this. They have only to be fitted with bearings of maximum smoothness.

Then, by feeding the oil to be tested, so as to provide a surplus supply, the differences of resistance due purely to viscosity will be measurable, and the results will apply to the case of the cotton spindles. Other things equal, the oil of the least viscosity gives the least resistance, and, in this case, all other things are equal for a large number of oils.

As between sperm or lard and a mineral oil, however, there would be an element which the testing machine could not show; that is the tendency of the animal oil to gum by exposure to the air and dust. The necessary time of exposure would be so great that it would be impracticable to show this phenomenon on the testing machine.

The latter's sole function would, therefore, be the measurement of the relative viscosity, which the experiments of Waite¹ show could be as well done by noting the time of flow out of a pipette.

Case 2. Let us suppose that a rolling mill manager having heard that the oil-testing machines have saved considerable money to cotton mills, by showing them better oils than lard or sperm, concludes to resort to this method of investigation to decide between such lubricants as are offered for general service on their machinery.

The latter is of the heaviest description, viz.: roll trains whose bearings, when rolling heavy masses of iron, are subjected to the most violent strains, and are accessible to all sorts of dust. The usual lubricants are the most viscous kinds of oil and greases.

These are tried upon the oil-testing machines in comparison with lard oil, and are found to have several times greater frictional resistance at ordinary temperatures. The testing machine is found to behave very irregularly when the oil is applied in the irregular manner common in the mills.

¹ Trans. N. E. Cotton Manfg. Association.

The operator can see no regularity in his results, unless the supply of oil to the testing machine journal is made so superabundant that no momentary deficiency can exist. He also finds that, even with a surplus feed of oil, he can have no uniformity of results, so long as the brasses of his testing machine are as rough as are the bearings on the machinery in the mill. No attempt is made, therefore, to copy the condition of roughness of the bearings of practical service. Uniformity of results strikes the operator as essential above all else.

The sole element of equality between the conditions on the testing machine finally becomes the pressure per square inch, and the rubbing speed. The pressure may reach 500 lbs. per square inch.

The test is made at this pressure but the rate of feeding the oil is artificial in its surplus character, and hence, there is no possibility of its being momentarily deficient; also, the surfaces have become polished by long running, accompanied by a constant lateral movement lengthwise of the journal, either automatic or maintained by hand. The surfaces do not need to be free of cinder cracks or of scratches, but they are prevented from wearing to fit each other in rings or grooves by the lateral motion. The result of the test is, that the friction of the greases and the thick lubricants, such as heavy petroleum cylinder oil at ordinary temperatures, is several times greater than lard or sperm oil. The operator reports this fact to the mill manager and the latter may attempt to apply it in his practice, by changing to lard oil, which we will assume can be had as cheap as the thicker lubricants. Immediately the fact will exhibit itself that it is impossible to maintain satisfactory lubrication about the mill machinery, without expending several times more¹ lard oil than has sufficed with the more viscous lubricants.

It is impossible for any one to appreciate through the medium of the mill machinery that there is less friction with the lard oil than there has been with the viscous lubricants, because the friction of the bearings is so trifling a proportion of the whole expense of power, which is mainly absorbed by the resistances of the iron squeezed in rolls. If the lard oil is supplied in sufficient abundance to insure plenty of it being available at every spot of the bearing there will be no overheating or cutting. But the whole system of feeding the bearings, or the amount of attention necessary to supply the

¹ *Vide Comparison of lard oil with more viscous oils on large rolling mill engine.*
Paper COLXXXV, Vol. IX, Trans. Am. Soc. Mech. Engineers.

oil will be so much more troublesome to the workmen, that the lard oil would not be fed with sufficient regularity to prevent occasional deficiency of supply, and the probability is that overheating or cutting would occur with it, which might never have occurred with the more viscous lubricant. The fact will be learned in this case that the sole element of value in a lubricant, in rolling mill work, is the slowness with which it will allow itself to be squeezed out from between the bearing surfaces. And this quality belongs in the highest degree to the most viscous lubricants.

The reduction of friction, so far as it depends on the difference of resistance due to viscosity, is of no consequence in this case, and the metallic wear of the bearings is practically absorbed in the roughness of the surroundings, although, so far as it is concerned, the more viscous lubricant affords the least wear. What has the testing machine told us in this case, that is of value?

Only that greater viscosity makes more friction, which we again could determine by running the oils through any sort of orifice at some temperature at which they were fluid, or by observation direct, but which is not a sensible factor in rolling mill lubrication.

Case 8. Consider now heavy marine engines. A large number of engineers will say that greases are the most economical lubricants for such service. Such greases are applied in the best manner by "grease cups" having a piston forcing the grease upon the bearing by spring pressure. Or else a copper rod rests upon the bearing and penetrates the grease. If the shaft or bearing becomes too warm by increase of friction, the pin melts some of the grease, and the latter supplies itself to the journal, which then, generally, is sufficiently well lubricated.

It is held that, while the greases cannot lubricate a bearing which is roughened or sore, as well as oil plentifully fed by a wick or some form of constant feed oil cup, yet, on the average, the expense of lubrication by grease is far less than with the oil, because the grease will feed itself at a slower rate than is possible with the oil. Let us turn to our testing machine and test upon it the grease fed with the spring cup or the copper rod, and compare the results with lard oil fed with wicks at about the same degree of plentifulness common in marine works. Again we meet the irregularity of results referred to in Case 2, so long as the bearings are as rough as we would find them on the majority of marine engines, and we eliminate this element by nursing the journal to unusual smoothness.

There is, then, no definite difference in the friction when there is plenty of each lubricant on the journal, but occasionally there is a deficiency of grease supplied, despite the operator's efforts at feeding, and the friction is then temporarily greater than with the oil. On the whole, the grease gives more friction than the oil, unless the temperature of the bearings is allowed to be upwards of 25 degrees higher than with the oil. The marine engineer will agree that the bearings always do feel a little warmer with the grease than with the oil, but he cannot see that the extra heat interferes in any way with the best performance of the engine as obtained with oil. There is no greater metallic wear of the bearings; but the saving in the amount of lubricant consumed is so large that it outweighs every other qualification. He will carry for emergency some fluid oil, because occasionally some bearing will overheat from some cause undefined, and the temperature will rise to an excessive amount in so short a time that the grease cannot supply itself quickly enough to prevent a dangerous amount of cutting. He then falls back upon the fluid oil for a few days, because its supply can be perfectly controlled so as to insure no deficiency at any spot of the journal. What has the testing machine with its smooth journals told us that is of value to the marine engineer? Again only that the grease has more viscosity resistance than the oil.

Case 4. The locomotive engineer, learning of the economy due to greases in marine work, tries it as a lubricant on the crank pins of his engine where oil cups are available.

He uses the spring piston feed cup, and finds the grease runs the engine fairly well. He notices that the bearing is a little warmer than with his oil, but that the temperature does not steadily increase as it does when something is wrong with the bearing surfaces and a hot box is breeding. This fact is explained to him by the grease agent to be friction due to a little greater viscosity, but the viscosity is called "body," and a lubricant possessing more body than lard oil or engine oil common to locomotives is an idea which seems to the engineer an improvement, especially if the greases are going to save on the quantity of lubricant used, as he understands they have done in marine service.

So he makes a faithful trial of the grease without any overheating occurrences. But he finds little or no saving in the consumption over oil. When he used oil with a needle feed oil cup adjusted carefully as he has long since learned to regulate it, he could run a

thousand miles without exhausting the small sized oil cup used on the crank pins. He finds that he cannot do sensibly better than this with grease; also, that in the long run about as many cases of overheating occur. Again, when there is overheating, although the grease flows from the grease cup with a sudden abundance, it is too late to save the overheating, while the increase of consumption over the oil is then unquestionable, especially if he must soothe the journal by a temporary use of oil, as is usual. The explanation of this difference of the relative value of the grease in the marine case, and the present one, is that the rate of consumption of oil to which the marine engineer is accustomed, from the use of his "wick feed," is greatly in excess of the rate to which the locomotive engineer has been educated in using the needle feed oil cup. The latter is adjusted so that no oil will run out at all without the creation of suction such as is formed by the rotation of a shaft into whose brass the oil cup is tightly screwed. Another case under the same head.

A large electric power station transmits all of its power through a five-inch counter shaft running upwards of 350 turns per minute. The pressure is not as great as in marine engines but the rubbing speed is high for shafting, and it is thought that a great deal of "*body*" should be given to the lubricant, to provide for unusual conditions of severity as a good margin.

Accordingly, grease is adopted as a lubricant for the counter shaft. It is fed through open holes at two points in the boxes which are kept full of the lubricant.

It is found impossible to prevent the bearings running very warm. There is no apparent cutting of the bearing, and when the latter are too hot to touch, the proportion of power necessary to drive the shaft is not an important factor in the entire expense. But the bearings are babbitted, and it is not desirable to approximate to the melting temperature of the babbitt. Whenever the attendant fails to churn the grease in each box every few moments, so as to force it down upon the journal, a thin film of smoke will rise from the grease box. All sorts of greases are tried, those easily melted and harder ones, but no practical difference can be found in the behavior of the shaft. Finally, the manager studies the condition of the interior of the bearings, when the latter smoke, and just after the grease has been churned so as to do away with the smoke. He finds that the oil grooves fill up and prevent flow of the grease as

soon as the churning of the latter ceases. He is much impressed at once with the influence which is exerted by irregularities in the rate of supply. He understands that he can assist in the regularity of this supply by using a proper feed rod or a spring piston to feed the grease, but he believes that if a surplus supply is needed it will be best available with the most fluid form of oil; he therefore resorts to a mixed oil of great fluidity, that is, less viscosity than lard oil,—an oil approximating to that used for spindles in the cotton mill.

He feeds it by a sight feed oil cup dripping upon the boxes through the grease openings at such a rate that a steady stream of oil runs from between the rubbing surfaces at each end of the journals. This is caught, strained, and used over again. The result is that the shaft never gives any irregular heating and the bearings are much cooler.

But their temperature is always considerably above what would be considered satisfactory in marine or locomotive work. The reason of this is, not that the friction is above the lowest minimum probably available with any lubricant, but that the speed of electric light shafting is much greater in proportion to the area of radiating surfaces which naturally surround bearings, than in locomotive work. From these several instances we may learn the following: First, that any such idea as that oils have certain powers of resisting wearing out, which differ largely among the various oils currently used, is an absurdity, since the rates at which oil spent or consumed vary enormously with different classes of practice, and the most economical conditions of practice, where oil is fed through needle feed cups, as on locomotive crank pins, and light mill shafting, cannot be any measure of durability, for the oil escapes from the journals by capillary action so fast that it has no time to be depreciated in its wearing qualities. It is capable of filtration and repeated use after escaping from any practical journal where used with the minimum rate of feeding possible. In a special article¹ devoted to the subject of durability, I have presented facts which I think prove conclusively, that the durability of lubricants depends upon the rate at which they will feed on to bearings and escape from the latter, and that the greater the viscosity which an oil may possess without being incapable of feeding to a journal at a uniform rate, the greater will be its durability so far as such a quality

¹ Vol. XI, Trans. Amer. Soc. Mech. Engrs.

exists. Second, that absolute uniformity in the rate of feeding oil or any lubricant, exerts the most important influence of any element entering into the determination of its ability as a satisfactory lubricant.

Now of what value is our mechanical test on our oil-testing machine as a factor among these problems?

Answer. Used with ultra smooth bearings and a surplus feed, we should have once more only the differences due viscosity before us. And these differences have played no part in the heavy machinery instances cited, because the extra friction due differences of viscosity was of no consequence compared to what was effected by differences in the uniformity or rate of feeding the oil. If our oil-testing machine should be tried with the same form of oil cup used on the locomotive, and with the grease fed by churning through feed holes, and with the surplus drip feed adopted in the electric light station, and on dynamos generally, information of interest and in conformity with the actual experiences would be obtained, which would be valuable in tending to educate practical men to take more intelligent views in these matters. So far as I am aware, however, little or no such work has ever been done with mechanical oil-testing machines, because the operators make it a *cardinal principle at the outset to eliminate all irregularities of behavior due to irregularities such as practice bases all its distinctions upon.* Also, the oil-testing machine must study the action of the lubricants upon bearings as rough and as variable in their condition as are the practical bearings which have no chance to become artificially smooth, from the fact that few of them have lateral movement, and because they are frequently accidentally abraded so as to disturb their surfaces out of a condition of minimum smoothness. I am aware that there have been occasional brief investigations with oil-testing machines in railroad laboratories, which have attempted to copy the rates and methods of feeding abounding in practice, but I have yet to hear of any investigation made without artificially smooth surfaces, or surfaces incapable of causing excessive heating with any form of current lubricant.

Case 5. Consider now the case of railway car lubrication. The circumstances are more interesting, I think, than those of any other class of lubrication. The three elements which determine the value of a lubricant for railroad car service, so far as it can be definitely discussed, are the cost due consumption of lubricants, the cost spent for coal to overcome the frictional resistance caused by

use of the lubricant, and the cost due to the metallic wear on the journal and the brasses.

We have seen how in cotton mills the cost of the power is alone to be considered, that in rolling mills and marine engines the cost of the quantity of lubricant used is the only important factor, but in railroads not only do both these elements enter the problem as tangible factors, but the cost of the wearing away of the metallic parts enters in addition, and furthermore the latter is the greatest element of cost in the case.

Assuming ordinary prevailing prices for oil, if the consumption of the latter costs one unit, the coal to overcome the friction of the journal only (not including wheel flange resistance, or rolling friction, or wind resistance) is about three units, and the cost of metal worn away is about six units. In no other service is there so rapid a rate of metallic wear. Such wear comes about first, from the heavy pressure and rapid speed of running to which the bearings are subjected; second, from the fact that the lubricant is always mixed with more or less grinding ingredient; and, third, because there is a constant movement of the brass lengthwise of the journal. The latter feature is peculiar to car service. A railroad brass which has not overheated itself has given to it a surface absolutely devoid of all circular grooves or lines.

General machinery bearings always present such circular lines, and their friction is always greater on this account than is that of the well worn journal of a railroad car.

I believe it is a well-established fact that a bearing not having constant end play rarely affords a friction less than five per cent¹ with ordinary rates of feeding oil.

But in railroad practice bearings which are planished by the constant endplay readily afford a friction of a fraction of from one per cent to one and one-half per cent, with any of the methods of feeding from a bath, to pads or saturated waste, and including conditions of the oil varying from freshness to that acquired by several months' use in a car-box. So far as is now known, the frictional resistance of the journal is about ten per cent of the whole power exerted, so that a variation of friction on the part of the lubricant of fifty per cent, affects about five per cent of the coal consumption of the engine.

Such increase of friction represents about the greatest differ-

¹ Vide Computations of Coefficients of Friction of Actual Engines, "Stevens' Indicator," July, 1890.

ence of viscosity found among current lubricants, as say between lard oil and a petroleum cylinder stock; and it may readily affect the coal consumption to a sensible degree. On the other hand if, as is probable, the more viscous oil maintains a thicker film between the rubbing surfaces, the latter may touch less frequently and the metallic wear be less to such an extent, that the total expense of lubrication may be less.

But the more viscous lubricant may not have the ability to feed itself to the journal through the medium of the waste or feeding pad in cold weather. In this case journals run dry and overheat. It is a nice problem and one yet unsolved to determine just how viscous a lubricant may be the best under the circumstances. The average practice is to use an oil of about the fluidity of lard or neat's foot for the passenger or more important service and a much more fluid, purely petroleum, product for the freight service.

The oils stipulated almost universally for the passenger coach and engine service contain from thirty to fifty per cent of animal or vegetable ingredient combined with paraffine or what is known as a petroleum black oil of about 350° flash point.

The consistency or viscosity of such mixtures differs very little from that of sperm or lard oil. The specifications forbid the use of the pure petroleum oils used on freight service for the most expensive or responsible passenger traffic. There is clearly a belief throughout the whole of railroad practice that the oils used for freight service, which in general are subjected to less rubbing speed, are inferior as lubricants to the mixture of animal and petroleum assigned to passenger service. Yet, if the two classes of oils are tested on the oil-testing machine, the sole result which the latter affords by any present method of using it, shows that the petroleum freight oil has but about fifty per cent of the frictional resistance of the passenger mixture. The testing machine has its journals reduced to the artificial state of smoothness to which we have constantly referred, and the coefficient of friction shown under these conditions, at the average pressure and speed of rubbing which obtained in car service, is from one-quarter to one-half of one per cent. There is no doubt that the same coefficients obtain in actual service when bearings are well supplied with oil. *By the verdict of the testing machine, therefore, the pure petroleum oil is the superior lubricant.* Yet this oil is never intrusted with the lubrication of the traffic which is considered to require the best lubricant.

No specifications issued by railroads regarding lubricating oils have, I believe, yet ventured to stipulate any conditions of practical mechanical test as a measure of value of lubricants. This fact shows clearly that no basis of distinction for their lubricating oils has been found by using the testing machine under these artificial conditions, and no other conditions have been yet cultivated. When, therefore, the expert in charge of a railroad laboratory has placed before him a number of samples of lubricating oil, all apparently of the same fluidity and practically of similar composition, and is required to discriminate regarding their relative value for car lubrication by the use of a mechanical testing machine which simply measures the coefficient of friction and copies none of the conditions of service except the rubbing speed and the pressure per square inch, he must either acknowledge that the machine affords no means of making the distinctions required, or else he deceives himself by setting up distinctions which have no practical significance. One claim, made by experts in railroad lubricants, is that the thinnest or most fluid lubricant obtainable, is best on the ground that the power to insinuate itself between the rubbing surfaces is the controlling element in the success of a lubricant. On the other hand the opinion is put forth that the excessive pressure often brought upon car journals makes it a fact that greases are the only lubricants capable of withstanding this pressure and, as is well known, greases are extensively used as railroad lubricants in European practice. A simple experiment suffices to show that there is no practical difference of ability among lubricants of widely differing states of fluidity, to insinuate themselves between two fairly smooth surfaces which fit so closely that the film of oil cannot be less than a ten-thousandth part of an inch. Thus, if we smear the plug and ring of a half-inch standard gauge, with either lard oil, paraffine oil, or the thick, viscous oil which is used for cylinder lubrication, and which will scarcely flow at 70° Fahr., we find that the readiness with which the plug will enter the ring does not differ with these oils, and the plug is, according to Pratt & Whitney, not more than one thirty-thousandth of an inch smaller than the ring. With any of these oils we may slide the two pieces over each other. The force to move them will be sensibly greater with the more viscous oil. Also, if we cease to move the pieces, the interval of time in which they will become locked upon each other will vary from five seconds with the thinnest oil to as many minutes with the thicker oil, a fact which

simply means that the time for one oil to be squeezed through the annular orifice between the ring and plug varies with the viscosity. Therefore, the relative ability of lubricants to insinuate themselves between the bearings in car journals affords no basis for the relative valuation of lubricants. Regarding the pressure to which oil is subjected in railroad car service, it is probably more severe than in any other class of practice.

Car brasses, when used bare, are so imperfectly fitted to the journal that during the early stages of their use the area of bearing may be but about one square inch. In this case the pressure per square inch is upwards of 6,000 lbs. But at the slowest speeds of freight service, the wear of a brass is so rapid that, within about thirty minutes the area is either increased to about three inches, and is thereby able to relieve the oil so that the latter can successfully prevent overheating of the journal, or else overheating takes place with *any oil*, and measures of relief must be taken which eliminate the question of differences of lubricating power among the different lubricants available. A brass which has been run about fifty miles under 5,000 lbs. load, may have extended the area of bearing surface to about three square inches. The pressure is then about 1,700 lbs. per square inch. It may be assumed that this is an average minimum area for car service, where no violent and unmanageable over-heating has occurred during the use of a brass for a short time. Now this area will very slowly increase with any lubricant, and experiments can therefore easily be tried to determine whether the pressure which is brought upon a lubricant by such an area in car service excludes from use oils in preference to greases. The apparatus in which I have made such experiments consists of a railroad axle coupled at one end to a twenty-five horse steam engine, and supported at the other end upon thirty-three inch friction wheels. A twelve-inch wheel, forced on the axle as is the car wheel, serves as the rolling support upon the friction wheels. A regular car box can be used packed with waste or with a siphon pad, or a special brass having a perfectly cylindrical outer surface to receive the load, so as to make the line of the latter pass as accurately as possible through the centre of the journal. The load is applied by a steelyard and may be any amount up to 20,000 lbs. The friction is weighed by counterpoises on a lever fixed to the brass or bearing.

The resistance of the oil pad, or bath, is eliminated, by support-

ing the pad or oil bath on a bracket fixed to the main foundations of the machine.

With a load of 10,000 lbs. a variation of one lb. in the amount of the friction is easily distinguished at a speed equivalent to fifteen miles per hour of ordinary railroad service, but an eccentricity of the load of $\frac{1}{500}$ of an inch will destroy the absolute value of this indication. Provision is therefore made to run in opposite directions, and in determining the coefficient of friction this method is always used to eliminate the influence of the possible eccentricity of the line of the load which divides itself into two parts by links depending from each side of the brass to a cross head below the journal where connections with the loading steelyard are made.

Automatic means are provided of maintaining a movement of the brass lengthwise of the journal. A fan is arranged to throw a 14-inch stream of air against the box, in imitation of the cooling effect of the atmosphere to which a railroad box is subjected by the translation of the car. The essential features of the apparatus are similar to that used by Mr. B. Tower in his experiments for the English Institution of Mechanical Engineers, and a machine which I understand has been used for several years on the Brighton railway, England. Similar machines have been more recently erected at the Brooklyn U. S. Navy Yard, at the laboratories of the Eastern railway of France, and elsewhere. The only features which can be claimed as original are, first, the rolling support at the testing end of the axle, which eliminates all heating at this support from that due to the test bearing and permits the temperature of the latter to be a measure of its friction; second, the arrangement for unlimited driving effect by direct coupling to an engine; third, the provision of the cooling influence of the air jet.

All of these conditions are evidently essential to the *study of the action of lubricants under such imperfect conditions of bearing surfaces as give rise to excessive friction and overheating*. The machine is one of several pieces of special apparatus built for the Lubricating Committee of the Standard Oil Co.

The policy of this body is to seek a knowledge of their lubricating products by every method of test which can be regarded as at all capable of leading to definite measures of lubricating value having any tangible mechanical significance, or practically valuable in any reasonable degree. I am indebted to the courtesy of these gentlemen for the privilege of using their apparatus and making public

the results, as a purely scientific investigation. From extensive experiments with this apparatus, supplemented with minor devices, it results that *any lubricant*, even those of such extreme fluidity as we have described for spindle lubrication, that is, the lightest paraffines, run for hours by feeding through a pad and wicks, affords the minimum amount of friction, at axle loads as great as 10,000 lbs., with an area of only two square inches of bearing, so long as no accidental abrasion or cutting of the rubbing surfaces occurs.

We may therefore conclude that, so far as mere pressure between smooth surfaces is concerned, there is no basis for discrimination of value among current lubricants for car service, assuming them all capable of being applied in fair quantity to the rubbing surfaces. Without further extending our list of the different classes of service, let us face the question. What is the cause of the wide differences of opinion to be found in practice which testify to the existence of differences of lubricating value among oil, etc.? The answer is that all these differences are connected with the overheating of bearings, with the creation of hot boxes. Oils of the same appearance, fluidity and general qualities, do certainly differ in their ability to lubricate bearings which are overheated, or rather in their ability to reduce the frequency with which overheating occurs in a given bearing or set of bearings. A striking instance which has been brought to my attention is the case of some large engines which, having used lard oil for the lubrication of their crank pins, without trouble, changed to the use of a mixed oil of unknown composition, but which was apparently identical in lubricating ability. After using the new oil for a few days, excessive overheating occurred and the crank pins were badly mutilated.

Longitudinal grooves upwards of six inches long, one-quarter of an inch in depth, and one-half as wide, covered the surface of the pins. The first idea was, naturally, that the new oil contained some corrosive ingredient, but close examination showed this not to be the case.

Experiments upon the mechanical oil-testing machine with smooth journals and brasses showed no difference of lubricating value, as we have seen is always the fact. All kinds of journals, as regards openness of structure, were tried with the two oils as, for example, journals of steel and of coarse iron, with the grain parallel to the axis of the journal. There was no difficulty in obtaining as satisfactory coefficients of friction with the new oil, as with lard oil, with

the bearings in ordinary conditions of smoothness, and at ordinary temperatures.

But upon creating an abnormally high temperature such as 400 degrees Fahr., by running the oil-testing machine at a sufficiently high speed to prevent the natural radiation of the bearing surfaces from maintaining the temperature at ordinary limits, it was found that the new oil, which had given the trouble, gave a steadily increasing friction, which finally wore away the brasses so as to clog the oil holes and stop the supply of oil. It was then decided that the differences in the two oils must arise from a generation of heat due to accidental cutting caused by the constant and inevitable wear of bearings under heavy pressure.

Accordingly, test journals were artificially abraded by scoring them with a ragged ended steel point forced against the journal through a hole in the brass. The result was that the friction increased above the amount which would naturally maintain the bearings at ordinary temperatures.

But while such increase soon reached a maximum with the lard oil, with the new oil, the friction continually increased, until finally the journals were smoking and all the conditions of a genuine hot box realized.

The experiment was then extended by causing artificial abrasion with emery, with the same result.

It was then evident that the difference in lubricating value only existed when some accident caused abrasion, and generated heat, sufficient to vaporize the new oil under circumstances which did not vaporize the lard oil. By creating, in this manner, excessive friction, and persisting in the running of a journal for several hours while miscellaneous abrasion was taking place so as to score both journal and brasses, and using water to prevent the temperature of the bearings becoming greater than a black heat, that is preventing their becoming red hot, I produced a journal which was a fair reproduction of the mutilated crank pins just described.

It was then clear that the brass could tear metal from a journal along lines in any direction, just as a dull tool will tear metal from a cylinder in a lathe. If there are lines of weakness in metal such as may be due to mixed degrees of welding in a crank pin built up of scrap—these lines will probably aggravate the mutilation. But mutilation is always possible with any two metals as hard as iron on the one hand, and brass or hard white metal on the other.

Here is, I believe, a clew to the true solution of the problem, namely, that the only practical difference in the lubricating value of oils is in their respective ability to resist the action of sudden heating due to abrasion of the rubbing surfaces. It is only when the occasional overheating occurs that we hear anything about differences in lubricating value. Such abrasion results either from the gradual and inevitable variations of smoothness due to metallic wear or to accidental temporary interruption in the rate of supply of oil to a bearing.

Interruption of the uniformity of the intervening film of lubricant, between the rubbing surfaces, is a certain, and probably the far more frequent direct cause of the abrasion, but in the long run there will be cases, of this action, when apparently the utmost pains in feeding have prevailed, and the cause of heating must be attributed to the gradual changes of the surfaces, too slight perhaps to be discerned by the unaided eye, but which cause a temporary deficiency of oil supply at some point of the bearings. Either directly or indirectly, therefore, the uniformity, with which the lubricant insinuates itself between every part of the bearing surfaces, determines the success of the lubrication. With restricted or minimum rates of feeding, the capillary property of lubricants between two metallic surfaces probably controls the uniformity of the conditions of the oil film. Hence nearly every variation of ingredient of compounded lubricants may be accompanied with a difference of ability to cause the lubricant to supply itself to a bearing.

There is as yet, however, no evidence, capable of proving, that the broad range of viscosity available in the lubricating products of petroleum cannot afford a lubricant possessing any degree of capillary property to be found among the compounded oils. When the rate of feeding is comparatively superabundant, the rate of *escape* of the oil from the bearing may control the rate of supply. Consider once more the case of the car journal. The newly applied brass bears only in spots, as explained above. The coefficient of friction is then about seven per cent, but rapid wear creates a greater area of contact and a highly perfect condition of smoothness, so that in two and one-half hours the friction may be one-fourth per cent with any oil, and then the temperature of the brass settles to less than 100 degrees. But, on the other hand, instead of polishing itself, the bearings may abrade at a spot and then the heating will become excessive and no oil will control it. Thirty minutes of running will

then make the shaft actually red hot. There is always so much uncertainty about the brass wearing to the smoother and safe condition, that the invention of a lead lined brass was a great boon to railroad lubrication.

The soft lead lining cannot cut the journal, and it is impossible for the area of bearing to be less than several square inches for more than an instant of time at the start, as the lead flows under the pressure like a very thick grease. A journal excessively scored with a brass can be filed and then immediately reloaded, if a lead lined brass is applied, and no overheating occur.

But suppose that the bare brass has been successfully worn to the polished area which affords the very low coefficient of friction of one-fourth per cent. Suddenly, the friction may double itself with no change of any condition that can be discerned. If the rubbing surfaces are closely examined some very slight change of smoothness is apparent; but it would attract no attention if the friction index had not suggested a disturbance of perfect conditions. Gradual infinitesimal wear has caused the variation of friction. If the load is considerably increased after running some time at a fixed pressure with a minimum friction, the friction may suddenly increase ten times, and many hours of nursing may be required to nurse the bearings back to the minimum friction condition, yet the coefficient of friction will only then be about $2\frac{1}{2}$ per cent which will not produce a temperature sufficiently high to attract attention or cause complaint.

If a grain of dust or grit be thrown between the surfaces the friction will also suddenly increase.

Such variations are constantly going on with apparently a steady and sufficient supply of oil.

It is easily conceived, therefore, how in the midst of the many irregularities of car service such accidental variations of friction may occur as are necessary to bear out our hypothesis regarding the accidental generation of intense heat at portions of the bearing surfaces, and consequent disturbances of the uniform oil supply to every part of the rubbing surfaces, which finally results in excessive heating and mutilation of the journal.

Undoubtedly the most important element in lubrication is that oil shall reach every part of the surface.

Anything that induces oil to neglect to interpose itself between a spot of the rubbing surfaces is a possible cause of overheating.

Anything that improves the distribution of oil reduces friction. In this fact lies the explanation of the curious paradox that sand or emery, or grinding material of any sort, applied to an excessively overheated bearing, improves it. To understand how this can be, consider the action of a journal run without oil under heavy pressure. It is cut badly and the brass is clotted upon it. It then runs with a coefficient of friction of say forty per cent with lard oil.

We mix emery with oil to form a thick paste and apply it to the bearings at 1,000 pounds pressure per square inch. Instantly the surfaces are scored with grooves or rings, *but the coefficient of friction reduces itself to say eighteen per cent.* The emery has cut grooves for itself in which the particles roll with very little friction; for upon cleaning off the emery and running with clean oil the friction is no less. The grooves fit each other without excessive abrasion. The friction is still far above the four or five per cent which maintains the journals cool. There is, therefore, no conflict of the facts with the well known influence of grit in increasing the friction of a bearing in practically perfect condition. The conditions are, however, a great improvement over the dry brass-coated journal, *because the grooves cause a perfect distribution of the oil.*

Cooling compounds, or flour of sulphur, or ashes act on the same principle, but must be applied before the abrasion becomes so excessive, as they are comparatively feeble in their grinding properties. As long as the grooves fit each other, the friction will be no greater and may gradually become less than the eighteen per cent.

But if the brasses are forced laterally out of the grooves in the journal, or if a smooth journal is run with the grooved brasses, the corrugations in the surfaces are crushed, and the journal tends towards the condition of maximum friction once more as the brass begins to attach itself to the journal, and uniformity of supply of lubricant is destroyed. If the brasses are lined with some of the soft, anti-friction metals, however, the crushing down of grooves by a smooth journal does not cause excessive friction. Herein lies the true advantage of these metals. They afford no less friction than bare brass when both metals are equally smooth. Also when abraded by emery or other means, or when run without a lubricant, the friction is equal to that of bare brass, and any white

metal will eventually melt, if the brasses surround completely the journal.

But white metals are more rapidly worn to a smooth, or safe, condition than is brass, and better resist being disturbed from this condition. So that the *chances* of heating are less with soft anti-friction metal than with bare brass or hard, white metal. There are circumstances, however, when overheating will take place even with a lead-lined car brass. An instance of this occurred on a certain railroad. A considerable number of lead-lined brasses overheated. It was found that the lead had worn through to the brass at the middle and not near the ends owing to a variation in the structure of the brass. At the middle of the latter chemical analysis showed absence of phosphorus. Elsewhere the material was phosphor bronze.

The difference in the rigidity of the two metals induced such an unequal distribution of pressure that the uniformity of the oil film was unduly disturbed, and hence abrasion occurred at the middle, ending in excessive heating, and the final withdrawal from service of the particular lot of brasses in which the irregularity of structure occurred.

Enough has been said, I think, to show that the differences of lubricating value of lubricants, upon which the opinions of practice are founded, are not revealed by their behavior between rubbing surfaces artificially prepared and supplied, whatever the pressure and speed of our testing machines; but that to develop these differences we should provide bearings and conditions of feeding oil which shall provoke a range of irregular action by abrasion and heating, and then study the behavior of the lubricants carefully.

It is hardly necessary to state that under these circumstances, to determine the relative value of two lubricants in as many hours is an impossibility.¹

¹ For the details of some of the experiments upon which the above conclusions are based, see Trans. Amer. Soc. Mech. Engrs., Vol. XII.

PAPERS READ.

EFFICIENCY OF THE LOCOMOTIVE LINK VALVE GEAR COMPARED TO THAT OF THE MODERN AUTOMATIC HIGH SPEED ENGINE. By H. P. JONES, Portsmouth, N. H.

[ABSTRACT.]

The author has constructed curves having for their abscissæ percentages of stroke, and for their ordinates percentages of the total area of valve opening belonging respectively to the standard type of locomotive link motion and to the Ball automatic cut-off engine, at various cut-offs. These curves enabled tables to be prepared from which it appears that the automatic engine renders a larger proportion of the port area available than does the locomotive. For example, the automatic cut-off engine at 30 per cent cut-off permits 43 per cent of its total port area to be used, whereas only 27 per cent is available in the case of the link motion.

It is a natural inference that such difference of valve opening would cause considerable difference in the amount of wire-drawing or distortion during admission, as shown by indicator cards.

Examination of indicator cards from the two types of engine shows, however, that such is not the case, since for equal piston speeds and proportion of port area to piston area, the locomotive gear gives indicator cards quite as perfect as the automatic gear. The well-known distortion or inclination of the admission line of locomotive cards appears at piston speeds which require a mean velocity of flow of the entering steam above 250 feet per second, which, while frequently demanded in a locomotive, never exists in stationary engines which present more perfect indicator cards.

It was further shown by discussion of indicator cards presented that while the most perfect cards were afforded by "trip motion," cut-off gears like the Corliss, the following conclusions practically apply to all good valve gears including:

- The locomotive link motion,
- The automatic cut-off or high speed engine,
- The Meyer cut-off,
- And the Corliss cut-off.

1. To avoid more than one pound loss of pressure between the steam chest pressure and during admission to the cylinder, the mean velocity of flow of the steam through the ports during admission must not exceed 40 feet per second.

2. The admission line remains parallel to the atmospheric line up to a mean velocity of flow of about 250 feet per second, notwithstanding that the loss of pressure between steam chest and cylinder may be upwards of twenty-five pounds per square inch.

3. Distortion or inclination of the admission line occurs above 250 feet velocity of flow, and in locomotives at 55 miles per hour, the velocity of flow, is upwards of four hundred feet per second. Hence the loss of pressure between the beginning and end of the admission line is upwards of twenty-five pounds in this type of engine.

RESULTS OF TESTS OF PERFORMANCE OF SEVENTY-FIVE TON REFRIGERATING MACHINE, OF THE AMMONIA COMPRESSION TYPE. By Prof. J. E. DENTON, Hoboken, N. J.

[ABSTRACT.]

THE machine tested had a steam cylinder eighteen inches diameter and thirty-six inches stroke, and two ammonia cylinders twelve inches diameter and thirty inches stroke. The steam cylinder worked with double and the ammonia cylinders with single action. The speed was constantly sixty revolutions per minute. Tests were made at various back pressures from twenty-eight to six pounds per square inch. The supply of cooling water was varied so as to produce a range of condensing pressure from 105 pounds to 150 pounds to the square inch. The temperatures produced in the circulated brine, which received the refrigerating effect, ranged from zero Fahrenheit to twenty-eight degrees Fahrenheit. The ammonia circulated was metered in liquid form by a Worthington water meter of special construction. Nine separate trials were made of from twelve to twenty-four hours duration each. The results gave for the best performance a refrigerating effect per pound of coal equivalent to the production of twenty-four pounds of ice; when the back pressure was twenty-eight pounds per square inch, the condensing pressure 150 pounds per square inch, and the consumption of cooling water about one gallon per minute per ton of ice capacity in twenty-four hours. Such a back pressure does not permit the cooling of brine below about thirty-three degrees Fahrenheit, but the nominal capacity of the machine is then realized, the exact performance being seventy-eight tons per twenty-four hours. With the same condensing pressure, but with seven pounds back pressure, the refrigerating effect was fourteen pounds of ice per pound of coal consumed. The temperature of brine available with the lower back pressure was minus two Fahrenheit and the capacity is then but about forty tons per twenty-four hours as the ammonia circulated is reduced in amount in proportion to the back pressure. These two results were both obtained with the minimum amount of cooling water practicable, assuming the latter to be supplied at about sixty degrees Fahrenheit. By trebling the quantity of cooling water, the

condensing pressure was reduced to 105 pounds for either back pressure and thereby the economy was increased about thirty-three per cent. These results represent the best economy to be expected from the use of ammonia refrigerating machines driven by non-condensing steam engines. It was explained that the cost of cooling water at ordinary city prices for water was an equal factor of cost with coal in operating such machine. Attention was called to the fact that the influence of back pressure and supply of cooling water upon the economic performance were as important as is the effect of different rates of expansion and amounts of boiler pressure in the performance of steam engines, and that the failure of experimenters to take account of differences in these conditions in comparing results of tests of ammonia refrigerating machines has given rise to much erroneous belief regarding differences of economy of machines depending upon the same principles. Such is the case in the reports of tests published by Professor Schröter, in which the best results obtained from ammonia compression machines were gotten with upwards of thirty pounds back pressure and one hundred pounds condensing pressure. The former condition is consistent only with brine temperatures above thirty-two degrees Fahrenheit and the latter with an amount of cooling water impracticably expensive, where water is boiled. Should these results be reduced to the basis of the most economical supply of water, the economy would be thirty-three per cent less. It was shown that the experimental results were satisfactorily in accordance with theoretical computations of economy and capacity based upon the thermo-dynamic formulæ presented in the essay on ice machines by M. Ledoux and published in Van Nostrand's science series.

USE OF THE LOCOMOTIVE FOR TESTING CYLINDER OILS. By Prof. J. E.
DENTON, Hoboken, N. J.

[ABSTRACT.]

THE frictional resistance of an unbalanced slide valve in a standard sized locomotive when satisfactorily lubricated may be about 500 pounds.

A component of this force acts upon the reversing lever. If the latter be unnotched and held by hand the engineers can feel the increase of friction of the valve due to the extra steam pressure in the steam chest necessary to maintain a given speed with four passenger cars compared to three cars. The reverse lever is therefore available to test the relative friction of oils.

By gradually diminishing the amount of oil supplied to the cylinders, until some considerable increase of effort is necessary to hold the reverse lever still by hand and then trying different oils, a practical comparison of the friction reducing value of cylinder lubricants is available. The following results were obtained by the writer and are presented to show what may be expected from good cylinder lubricants by the above method

of procedure. The figures all relate to one oil, but probably a similar mileage could be obtained from other good oils as the increase of resistance to holding the reverse lever was not impracticably greater at these mileages.

**RESULTS WITH SIGHT FEEDING DETROIT LUBRICATOR ON STANDARD
LOCOMOTIVES 18 X 24.**

DATE.	JUNE 10.	JUNE 12.	JUNE 13.
Train	8 to 4 cars.	8 cars.	4 cars.
Distance	206 miles.	206 miles.	206 miles.
Average steam press	135 lbs.	135 lbs.	135 lbs.
Lubricator	Detroit.	Detroit.	Detroit.
Miles run per pint	440 miles.	515 miles.	380 miles.

EFFECT OF INTERNAL STRAINS IN HARDENED STEEL, PRACTICALLY CONSIDERED. By GEO. M. BOND, Hartford, Conn.

[ABSTRACT.]

MENTION of an instance of the return to a normal condition after excessive compression in hardened steel, by the fracture of parts adjacent was made by the writer, incidentally, at the 372nd meeting of the Society of Arts, Boston, March 1, 1888, and a statement was then made that in order to successfully maintain standard sizes represented by gauges made of hardened steel, they should be carefully "seasoned" before undertaking the final operations of grinding and finishing to these standard sizes.

The case cited was that of a cylindrical gauge, three inches in length, intended to represent accurately and permanently 2.8752 inches diameter.

Several days after finishing to this size the center of the cylinder suddenly gave way, leaving about three-quarters of an inch of length intact at each end.

Subsequent measurement showed an increase in diameter of the unbroken parts of about 0.0006 inch, and since that time, now nearly five years, only a slight further diminution of size is apparent.

The almost invariable consequence, following hurried finishing after hardening gauges made of tool steel, is a slight reduction of diameter at the extreme end—where the hardening is probably the most effective—and the practice of properly "seasoning," or allowing a year or more to elapse between the operations of hardening and that of final finishing to standard size has been found by the writer, in the work of which he has charge, to give satisfactory results in every instance.

The use of steel containing a low percentage of carbon, treated by the operation of "case-hardening," or heating in contact with material which supplies the necessary additional carbon for ensuring a hard surface when suddenly cooled, may tend to obviate this unequal internal tension; but the depth of the resulting hardening is so slight under even the best conditions, that it cannot be safely relied upon, if the article is to be afterwards ground and the finished surface uniformly hard, and especially so in gauges of large diameter; tool steel, having a sufficient percentage of carbon, being best in any case.

A DYNAMOMETER FOR MEASURING THE RESISTANCE OF METALS TO CUTTING AND BORING. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

IN this instrument the tool holder is mounted on a horizontal axle, working in ball bearings fixed to the slide rest of a lathe. The axle is hollow and for experiments on boring the drill forms an extension of it. The work is fixed to the live head-stock of the lathe and the drill is brought to be co-axial with it and fed forward by the ordinary feed mechanism of the lathe. The couple necessary to hold the drill from turning is measured by hanging weights on the end of a lever fixed to the axle. Vibration of the lever is prevented by causing one end to rest against a diaphragm forming one end of a short cylindrical box filled with liquid. A tube passes through the side of the box and communicates with a vertical pressure tube fitted with a conical valve, or stop-cock, by means of which the passage of the liquid can be throttled, thus giving any desired amount of rigidity to the diaphragm.

For experiment on cutting the tool is fixed to a holder forming part of the axle and the point brought to a measured distance from the axis. The couple required to balance the pressure on the point of the tool is then measured in the same way as in the case of the boring experiments.

DIAGRAMMING APPARATUS FOR USE IN TESTING MATERIALS. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

IN this apparatus the force coördinate of the diagram is obtained from the extension of a spring through which the force is applied to the end of the steelyard arm. The steelyard lever is fitted with attachments for moving a record surface which may be either a plane sheet or plate, or a sheet of paper laid round the surface of a cylinder. The extension of the specimen is recorded by means of a system of levers applied to two

points of the specimen and of such length as to give the record near the free end of the steelyard lever. Two diagrams are drawn one giving the elongation magnified four hundred times and the other four times. The first is intended for the elastic and the second for the permanent elongation of the specimen.

A NEW TRANSMISSION DYNAMOMETER. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

IN this dynamometer the power delivered by a belt to one set of pulleys is transmitted to another set, or to the work direct, through a shaft of such construction as to be capable of yielding considerably to the torque. The amount of this elastic yielding is measured by causing the relative motion of the two ends of the shaft to move a horizontal bar, the end of which presses against a pressure gauge arrangement similar to that described in the paper on the dynamometer for tests on the cutting and boring of metals.

PRELIMINARY EXPERIMENTS ON THE RESISTANCE OF METALS TO CUTTING IN LATHES. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

Cast Iron.—Experiments were made on the effect of speed and amount of cut. For speeds varying between 3 and 66 feet per minute the pressure required to make a cut $\frac{1}{16}$ by $\frac{1}{16}$ of an inch varied from 103 pounds to 93 pounds. The number of minutes required for one horse power to remove one cubic inch of material varied from 0.46 to 0.75 depending mainly on the size of the cut but also to some extent on the speed and the kind of tool employed.

Steel.—Experiments were made on two specimens of steel, one a low carbon machinery steel, and the other a hard locomotive axle. The first specimen cut much better than the second, but the power required to remove a given quantity of material was nearly the same. When cut dry both specimens offered less resistance at high than at low speeds. When the cut was kept wet by a stream of water the resistance reached a maximum at speed between 12 and 20 feet per minute above which it diminished. For a cut of over $\frac{1}{16}$ by $\frac{1}{16}$ of an inch the number of horse power minutes required per cubic inch was about 0.83 which may be reduced 20 per cent by lubrication with water or oil.

Brass.—In the case of brass there was very little effect of speed, the resistance only falling about three per cent for a change of speed from 3 to

60 feet per minute. The number of horse power minutes required to cut off one cubic inch of material varied from 0.27 to 0.5 according to the weight of cut taken; a somewhat heavy cut being most economical.

MACHINE FOR TESTING TORSIONAL STIFFNESS. By Prof. THOMAS GRAY,
Terre Haute, Ind.

[ABSTRACT.]

THIS machine is designed for tests of the torsional strength and stiffness of shafting. One end of the shaft is held in a grip which forms part of a gymbal arrangement attached to one side of a worm wheel. This arrangement allows the end of the shaft to be twisted round without their being any chance of cross bending stresses in the shaft. The other end is held in a cross bar which hangs from a beam like a balance beam. The beam is held horizontal by means of weights on a pair of steelyard levers properly connected to the ends of the cross bar in which the end of the specimen is held. The amount of yielding of the specimen is measured by means of apparatus fixed to the specimen and independent of the grips of the testing machine.

NEW PRINCIPLES OF MECHANISM SHOWN BY SPIRAL GEAR WHEELS WITH INVOLUTE TEETH. By O. J. BEALE, Providence, R. I.

[ABSTRACT.]

THE author has constructed a pair of spiral gears having a diameter of about two inches, a lineal pitch equal to the circumference of the pitch circle and involute teeth with the base circle coincident with the pitch circle.

A pair of such wheels of equal diameter will run together correctly when the axles are at right angles and the base circles tangent to each other. The teeth may be cut either with a planing tool or a cylindrical mill, as the line of contact is a straight line.

If one wheel drives the other in one direction only, neither need extend beyond the common perpendicular to both wheels. In this case motion may occur in either direction but a constant velocity ratio is obtained in only one direction.

If motion in either direction is required, one wheel must be superimposed on the other, so that each wheel extends beyond the common perpendicular. In the case of motion in one direction, the entire face of the wheel is available for action. But in the case of motion in both directions a portion of the face at the base of the teeth must be cut away. The reason for this fact is that points of the teeth near the base of a tooth describe spiculoids which lie within the involute outlines of the teeth.

ON THE CONSTRUCTION OF A PRECISION SCREW EIGHT FEET IN LENGTH.
A PRODUCT OF THIS SCREW EXHIBITED AND TESTED. By Prof. WILLIAM A. ROGERS, Waterville, Me.

[ABSTRACT.]

THE machine with which this screw was cut was constructed on the following basis:—

(a) The carriage on which is placed the cutting tool must be moved in an horizontal plane and the vertical ways must have no vertical curvature.

(b) The line between the centres must be parallel with the ways.

(c) The shaft to be cut must have its surface parallel with the line between the centres at every point.

(d) The errors depending on one revolution of the screw must be corrected independently of the linear errors which depend upon the position of the nut upon the screw. The latter errors are corrected by means of a templet.

It has been found by investigation that the maximum errors of the master screw do not at any point exceed $\frac{1}{100}$ of an inch.

A SIMPLE AND PRACTICAL METHOD OF SUBDIVIDING AN INDEX WHEEL INTO 1000 EQUAL PARTS. By Prof. WILLIAM A. ROGERS, Waterville, Me.

[ABSTRACT.]

THE method consists:—

(a) An approximate graduation into one hundred equal parts by means of a paper tape.

(b) An investigation of the errors of the spaces corresponding to each tenth of a revolution.

(c) An investigation into the errors of the ten spaces in each main group of tenths of a revolution.

(d) The combination of the errors thus found.

(e) Laying off a new set of lines into one hundred equal parts from the corrections thus found.

(f) Making a movable scale having a division equal to each hundredth of a revolution, subdivided into ten equal parts.

(g) In a wheel having an index four feet in diameter, the greatest error at any point after four approximations, was found to be only one three-thousandth of an inch. Laying off the one thousand divisions by means of two microscopes.

MONEY VALUE OF SOLID EMERY WHEELS. By T. D. PARET, Stroudsburg, Penn.

[ABSTRACT.]

DISCUSSES the elements of cost which determine the value of emery wheels, and shows by the results of recent extensive tests of fifteen makes of wheel, that many of the supposed conditions essential to the most economical use of wheels are fallacious.

A STANDARD FORMULA FOR EFFICIENCY OF STEAM ENGINES. By WILLIAM KENT, Passaic, N. J.

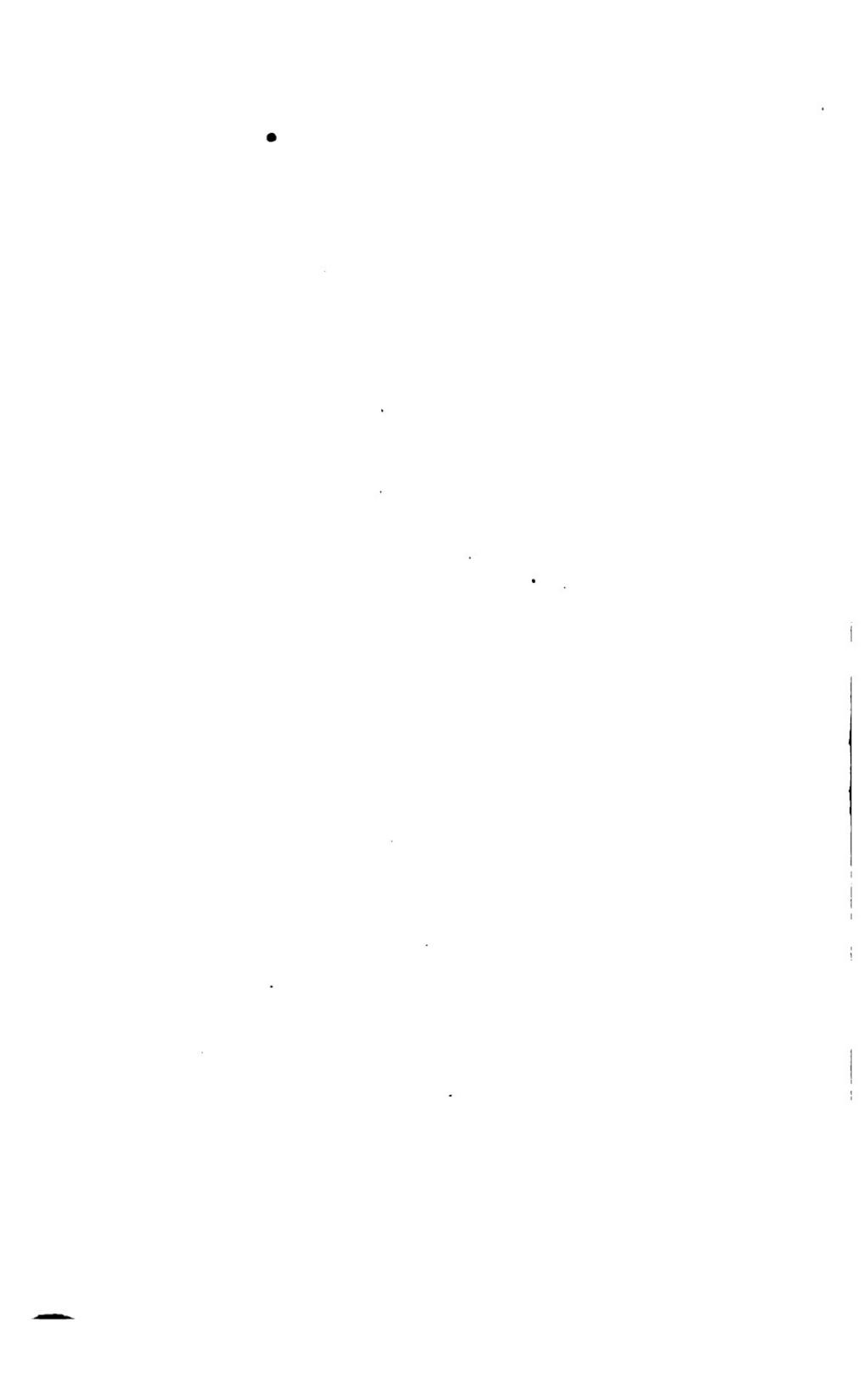
RESULTS OF TESTS OF STRENGTH OF SEWER PIPE. By M. A. HOWE.

THE STRUCTURE OF WOODS AS VIEWED IN THEIR CROSS SECTION. By W. J. BEAL, Agricultural College, Mich.

NOTE ON THE GRAPHICAL CONSTRUCTION OF CRANK EFFORT DIAGRAMS. By W. F. DURAND, Agricultural College, Mich.

ON A VORTEX AUTOMATIC LUBRICATOR FOR HIGH SPEED SHAFTS. By LT. JOHN DAY, London, Englaud.

WASTE IN MACHINE SHOPS. By OBERLIN SMITH, Bridgeton, N. J.



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ADDRESS

BY

PROFESSOR JOHN C. BRANNER,
VICE PRESIDENT, SECTION E.

THE RELATIONS OF THE STATE AND NATIONAL GEOLOGICAL SURVEYS TO EACH OTHER AND TO THE GEOLOGISTS OF THE COUNTRY.

The geologists of the country may be classified as follows:

- I. Professional geologists, connected with the United States Geological Survey or with some of the state surveys.
- II. Professorial geologists, or those teaching geology in our colleges and universities, and sometimes making excursions into the field either in the course of instruction or in order to carry on original investigations.
- III. Consulting geologists, or those doing private economic work.
- IV. Amateur geologists, including students who do volunteer work.

It is of the relations that exist, or should exist, between our national survey, the state surveys and geologists of the country, in whichever of these classes they may fall, that I propose briefly to address you.

Investigations are often undertaken in the course of instruction carried on in college laboratories, but it is rarely that individuals or institutions other than the state and the national surveys have undertaken extensive and expensive geologic operations. We must except, of course, in this statement those of an economic nature.

The reason of this is that individuals seldom and commercial organizations never devote their means to purely scientific investigations; and inasmuch as these investigations require large sums

of money, and as they are conducted largely with a view to increasing human knowledge, the expense of them must be borne by the public treasury.

With our official organizations most of the working geologists of the country, excepting those called consulting geologists, are connected—either as salaried assistants, permanent or temporary, or as volunteers. But these organizations carry on their work independently of each other, indeed without any regard to one another's existence, while individual investigators go each his own way pretty much as if he had the whole world of geology to himself.

If one has cause to be surprised at this lack of concerted action among men working upon the same and similar problems in the same country, we must remember that this state of affairs is the outcome partly of our democratic institutions and of our disposition to let everyone shift for himself, partly of the great size of the country, and partly of the fact that there has never been, until recently at least, any attempt or even any disposition to bring all the geological material in the country into harmonious action and relations.

We have done better in this respect of late years, but there is still much room for improvement. If there has been but little coöperation hitherto among geologists and between official surveys, doubtless it is because, as Professor Brice says of democracy, "It takes many centuries to form those habits of compromise, that love of order, and that respect for public opinion" which make good geologic work possible.

The United States Geological Survey.—The early geologic work carried on by the government in this country was done by military exploration parties under the War Department. Geology was in no case the prime object of these explorations, work of this kind being done by geological attachés of the parties. Geology came to be a more and more important part of them, however, until from 1867 to 1873 we had the surveys devoted principally to geography and geology under Clarence King and Lieutenant Wheeler, both of which were carried on under the War Department.¹

In 1869 the Geographical and Geological Exploration of the Territories with Hayden as its director was authorized under the Department of the Interior, and in 1870, under the same Department, the Geological and Geographical Survey of the Rocky Mountain Region under Major Powell was authorized by Congress.

¹A list of the commanders and dates of these expeditions is given in Ex. Doc. No. 240, 43rd Congress, 1st Session, pp. 6-8.

The operations of these surveys seem to have been carried on to some extent without regard to each other, for a part of the work was duplicated, and jealousy was aroused to such a point as to become a crying scandal to scientific work in this country.

This issue being forced upon Congress, in 1878 the National Academy of Science was asked to appoint a committee "to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general systems as will, in their judgment, secure the best results at the least possible cost."

The committee of the National Academy of Science was appointed and made the required report. It recommended that the surveys then in existence should be discontinued, including the Land Office surveys, and that there should be a single national geological survey which should deal with geologic problems, and that all mensuration should be done by and under the Coast and Geodetic Survey which should furnish whatever maps might be wanted.

The action suggested regarding the Coast and Geodetic Survey was not taken, but Congress discontinued the old geographical and geological surveys and the United States Geological Survey was established in 1879 as a permanent bureau of the Department of the Interior.

In the reorganization of the national survey, after the extinction of the old surveys, most of the men from all the former institutions were retained. This is where we find ourselves to-day with our United States Geological Survey.

It is not necessary that I should speak of the functions of this national survey as defined by law, for in a general way you are all familiar with them, while the business organization and general plan of carrying on its work are set forth in the eighth Annual Report of the Director (for 1886-7).

Practically it has *carte blanche* to carry on geologic investigations over the whole territory of the United States, and in every branch of scientific work directly related to geology, such as geography, topography, paleontology, physics, chemistry and statistics.

Now over this same area, though limited to the states carrying them on, we have our several state geological surveys; while private individuals, educational institutions, scientific societies and

commercial corporations are at liberty to carry on such investigations as they see fit, and all regardless of each other.

It would be very natural to expect that there would be more or less serious conflict between organizations and individuals working, as these do, upon the same questions and over the same areas.

In the earlier work carried on by the federal government, however, the various territories were the specified areas to which the national surveys were confined, and now that the whole area of the United States is open to this work, a broad-minded and coöperative direction seeks to aid and strengthen the state organizations instead of antagonizing or annihilating them.

But I wish to emphasize the fact that the classification of the geologists of the country, the work within the domain of the national survey, the work within the domain of the state surveys and that which can be or will be accomplished by private institutions, corporations or individuals, demand that there should be some more definite or better organized coöperation or coördination in all this work and among all these men.

The success of commercial and industrial enterprises the world over has been due to a greater or less extent to concerted action. In educational matters where action has been concerted and efforts and means concentrated there have our most marked successes been. Geologists may disregard the advantages to be derived from such coöperation, but it must be at their own expense and at the expense of the science.

And without doubt one of the reasons that coöperation has not been further practised than it has been is, that a sort of antagonism between older organizations has been handed down to us, and also because it takes time to bring into harmonious action a large number of men scattered over a vast territory and variously interested in widely different phases of geologic problems.

The statement has been made that the United States Survey does coöperate with very nearly every state survey in the country, but the fact is that the national survey does not know what the state surveys are doing except in a very general way, and that the state surveys know but little or nothing of what the national survey is doing, except perhaps as it may happen to be picked up in private conversations and in private correspondence between personal friends.

Please bear in mind that this is not intended as reflecting upon

the Director of the United States Survey; coöperation can only exist by the common consent of all the parties concerned, and it is quite as much the fault of the state surveys that there is no such coöperation as it is that of the United States Survey.

I might cite the case of a state survey of which I have some knowledge where the national survey carried its topographic work forward without any reference to what the state survey needed, for it did not know the state survey's needs, and when, almost by accident, the state survey learned of the government work, that work had gone too far to be modified to suit the needs of the state survey.

When I found myself a state geologist and began to look about me, and when I saw the relation in which a state survey stands to the national survey, I confess that I felt very much as the cock did when he was put in the stable with the horse. The cock sought to get on a proper footing with his companion by saying "Now, let's not step on each other," and if I did not do likewise, it was not because I did not see that I was as completely at the mercy of the United States Survey.

I mention my own case partly because I know more about it than any other, and partly because I am responsible to a great extent for the absence of intelligent and economic coöperation in the work done in the state of Arkansas.

The conclusions which I have reached then in regard to the relations that exist and those which should exist between the surveys and the geologists of the country are the result of my own experience and my own convictions confirmed by the experience and convictions of others—and that is that we should come to some understanding about what each one shall do and shall not do.

What I have to say, however, refers to the internal arrangements and the working of geologists as affected by our own bearing towards the official surveys, towards each other and towards the science rather than towards official relations and towards legislation. For these are not matters to be fixed by laws; laws would interfere with that freedom of movement that gives health, vigor and activity to our scientific bodies and to our scientific men; they can only be determined by common consent and by usage.

To begin with there should be some unanimity among all geologists about the scientific standing of our government and our state surveys, and about what each one can do and ought to do.

First in regard to the United States Geological Survey:—

This institution stands at the official head of all our surveys and of all our geological work.

Every statesman recognizes the fact that science is an element of prosperity and power which it is the duty of the state to foster just as it should foster other elements of progress and civilization, and it should fill every geologist with the profoundest gratification that our statesmen realize the importance of the general government giving liberal support to geologic work.

We must all of a necessity take a deep interest in the organization and conduct of this our national survey, for the work to which it is devoted can only be done by the aid of the government, and should that aid fail, either on account of proper organization or inefficiency, or on account of jealousy, or for any other reason, the progress of the science of geology in this country would be seriously impeded if it did not come to a dead halt.

We have reason also to congratulate ourselves and to congratulate the country that since its reorganization in 1879 there has been in the directorship a geologist in sympathy with all branches of scientific work, and at the same time a man who does not shirk his duty in the survey's relations to Congress. Not a few scientific men have false notions of their personal and professional dignity when these affairs crowd upon their attention. We need only remind ourselves that appropriations are quite as essential to geologic work as workers are, and that this part of the business can no more be neglected than any other part of it.

Just think where we should have been if no efforts had been made to lay the truth before legislators. Congressmen are busy men, too busy to go out of their way to look up worthy institutions that need support. All that enlightened statesmen want to know is the needs, demands and uses of these surveys, and they will see that they are properly supported; but how are statesmen to get this information if some well posted geologist does not furnish it? Statesmen must depend on geologists for such information as will enable them to act intelligently, and it is as plainly the duty of the director of the United States Survey to inform Congressmen and Senators of the needs of geologic work in the country as it is to carry on the work itself. It is a duty he owes to the people and to science.

National work encourages and stimulates state work, and state work reacts in favor of national work and both stimulate private

enterprise and investigation. The return from all this no man can measure, for it is both material and intellectual, and in both these senses it is felt in every nook and corner of the land.

The national survey is thus doing a work that no other institution can do, and it is able to maintain an organization of geologists that no other institution could maintain. For nowhere, in no country is there, and at no time has there been a corps of working geologists superior to that of our present national survey—a body of geologists, of which every scientific man and indeed every citizen of this country may well be proud.

Having no connection with that organization, either present or prospective, I feel at liberty to express this—a frank, disinterested and independent judgment; and I take the liberty to express the conviction just here that no more amazing thing can be found in the annals of science than that there are geologists—men who claim to be interested in the advancement of science—who would be glad to put an end to our national survey, the institution that has, as it were, laid the golden eggs of geologic science in this country.

The National Survey and the State Surveys.—With this splendid equipment of men and of means, what can the national survey best do and best leave to state surveys and to private enterprise? The question is not asked as implying that the officers of that body are not perfectly competent to decide these matters, but because we feel that a more effectual coöperation can be brought about to the great advantage of everyone concerned. So long as more than one organization must occupy the same field, some understanding can certainly be arrived at that will prevent the duplication of work and the waste of energy and of funds.

The appliances, libraries, laboratories, equipments and the large number of special assistants required by a national survey are quite beyond the means of our modest state surveys.

The great size of our country, the wide sweeping character of its general geologic structure, and the limits placed by civil boundaries on state work must throw most of the important general questions into the hands of the national survey. Local details can and should be worked out by the state surveys, and these results should be placed as soon as possible at the disposal of the specialists of the national survey. It is self-evident that problems that can be solved only after a wide experience and acquaintance with

the whole country cannot be satisfactorily undertaken by the state surveys, but that they must be solved by the larger and stronger organizations.

There are certain classes of work that, of necessity, fall upon a national rather than upon the state surveys: such are triangulation, precise levels, topography, paleontologic work, almost all investigations falling under the head of what is usually known as pure science, and all those investigations requiring much time and labor and money and many specialists. The reasons why state surveys cannot do work of this class are not far to seek. The men with whom the national survey has to deal are our broadest-minded statesmen — men who comprehend the scope and importance of purely scientific work, while, as a rule, state legislators look to immediate and what they call practical results. Such men cannot be convinced of the importance of any work that looks not to the immediate material prosperity of the state, while they are but little concerned, as a rule, with the intellectual income from it.

It is entirely beyond the means of any state survey to make a topographic map of the entire area of the state; the best it can do is to select a few typical areas and map those.

But maps are absolutely essential to satisfactory geological work, and map making has come to consume a constantly increasing share of the money appropriated for geological surveys, both state and national. The national survey, however, having large appropriations for topographic work and contemplating as it does the mapping of the entire area of the United States, ought to do this work.

That these maps must meet various demands and must therefore be constructed with varying degrees of accuracy and detail everyone will admit. As a matter of fact, however, the maps made are usually, as they should be, parts of a plan, and upon a scale for mapping the whole of the United States. This plan and scale may be perfect for that particular purpose, but it often happens that neither the plan nor the map is adapted to the purposes of the state surveys. And certainly nothing can be plainer than that the maps made by a geological survey ought to be available for geological work, or that, failing to meet the demands of geology, there is no geological excuse or reason for their existence.

Take for example the topography of the glaciated area of the Mississippi valley. The region is one of but little relief, and, in order to bring out this relief, the contour intervals must be very

small. But the contour interval on the United States Survey maps is 50°, one that completely ignores the delicate topographic character of the glaciated area of the Mississippi valley.

It follows therefore that the plan for topographic maps should be sufficiently flexible to meet the demands of those by whom and the purposes for which they are to be used.

Geodetic work cannot be carried on by the states because states are but small parts of and furnish but a few points in geodetic questions. European countries have even been obliged to unify their work. In the United States, work of this character must be left to some institution of the general government.

That paleontologic work should be relegated to the national survey seems to me scarcely to admit of question. The reasons for such assignment are briefly as follows:—

I. It is a piece of purely scientific investigation, the importance of which state legislatures as a rule do not comprehend.

II. The investigation demands a knowledge of the fossil fauna of not one state alone, but of a great many states and often of the fauna of all the explored rocks of the earth, while the observations limited to a single state are sure to lead to duplication and to erroneous conclusions.

III. The work can be properly done only by specialists whom state surveys cannot afford to employ.

IV. The illustrations necessary in a paleontologic report are too expensive to be paid for out of the modest appropriations made for state surveys.

It might be urged against these reasons that the states of Illinois and New York afford striking examples of the fact that states may, can and do carry on a high grade of paleontologic work. But it should be remembered that the conditions under which these excellent results have been obtained have passed or are about to pass away. For while the states of Illinois and New York have grown in wealth and intelligence since their surveys were begun, the legislatures of those states could not to-day be induced to take up and carry forward works of so purely a scientific nature, and if those states could have seen the end from the beginning, it may well be doubted whether they would have undertaken the great paleontologic investigations carried on so long and so successfully by Hall and by Worthen.

Another point which I must insist upon is that it is the place of

a state geological survey to do what is wanted in the state, and as a rule economic results are wanted. The people are entitled to what they pay for. Not that the survey must go on every wild-goose chase suggested, and examine every prospect and claim in the country, but the problems which the people wish to have solved should be solved if they can be.

These very demands define the work of the state surveys and separate it pretty sharply from that of the national survey.

If we are to be perfectly honest with ourselves we must confess that the state surveys have, as a rule, failed to do what the people have expected of them, and one of the principal reasons for these failures is that the geologists have not had the counsel and coöperation of a national survey. The geologists who have encouraged the making of appropriations for the work have invariably held out the hope that these surveys should be devoted to economic geology, while members of legislatures who have supported such bills have invariably done so in the expectation that they would do something of direct economic importance. But there are but few exceptions to the rule that these state appropriations have been devoted to paleontologic problems and to pure science, while economic problems have been entirely lost sight of.

These economic problems, or such of them, or rather, perhaps, such phases of them as can safely be dealt with by the state, should be the special province of the state survey, while the broader questions which can be satisfactorily studied and safely discussed only over wide areas should be left to the national survey.

It is true that economic and purely scientific problems cannot be entirely separated, and there is no necessity that they should be, but geologic work may give preference or prominence to one or to the other phase of the question, as the case may demand.

Some geologic problems naturally precede others, and if we work intelligently, we must take up these problems in their logical order. But in state work this is seldom possible, for state geologists must do their work in an order made necessary, not by geology alone, but by some economic consideration it may be.

I have said that economic problems should, in so far as possible, be left to the states. There are cases, however, in which this can not be done, for there are often those which, requiring study over a wider area, cannot be solved in a single state. These should be studied in part or entirely, as the case may demand, by the national

survey. Take for example the lead ores of the country; these ores occur in several states, and in each case it may be under somewhat different circumstances. Now the study of the origin and distribution of lead ores should be taken up as a whole, and not simply as a local question, for it cannot be satisfactorily studied and discussed in any single place.

If geology is studied as it should be, the student must be at liberty to move about as the exigencies of his work demand. This is not permitted by state surveys, and even if the employés of a state survey felt themselves at liberty to travel all over the country studying the questions with which they have to deal, they have not appropriations large enough to admit of the heavy field expenses required for such work.

Take again the subject of glaciation; how would it ever have been possible for any one, confining his observations to any single state, to have formed an opinion or to have reached a conclusion, worthy of utterance, regarding glaciation. And I venture to say that if there is still a good deal to be learned before we shall fully comprehend the history of the continent during Pleistocene times, it is due to no small extent to the fact that our observations have not yet taken wide enough range.

To be sure there is local work enough on this subject and to spare, but the great question as a whole could never be comprehended, stated, studied or solved in any single state, or indeed at all, unless one had *carte blanche* for his movements.

Professor Irving has well remarked,¹ what "countless, interminable wranglings as to stratigraphical correlations in the states east of the Mississippi . . . might have been prevented had any one geologist been able to follow through its whole extent the formation he was studying." But the state geologist is stopped by state boundaries, and the broader questions of stratigraphy and correlation cannot be settled or even satisfactorily discussed by him.

It seems plain, in so far as the relations between the national and the state surveys are concerned, that the national survey should leave all that it can safely leave to private enterprise and to state surveys, and that it should deal with those problems which state surveys and individuals will not or cannot satisfactorily deal with.

It is my opinion also that the national survey, being better in-

¹ The School of Mines Quarterly, Vol. IV, No. 4, June, 1883, p. 288.

formed of what is going on in the way of geologic work than the state geologists, and being in every respect the strongest of our organizations, should hold out a helping hand to the state surveys, and from their wider and more valuable experience give advice and encouragement to state work. In this way state aid to scientific work would be encouraged and the national survey would widen its helpful influence.

It goes without saying that state and national surveys should not ride rough shod over each other just because there is no law to prevent their duplicating each other's work or their doing work that will interfere with each other's plans or efficiency. It would be easy for a government survey to discredit and embarrass a state survey to such a point that the state would put a stop to its own work. Fortunately our national survey has been conducted rather with a view to aiding the state surveys. But this aid can be made much more effectual than it ever has been, and I have no doubt it will be made so whenever we are all ready for such coöperation.

The United States Survey and the Colleges.—My own conception of scientific organizations is not that they should simply devote themselves to the accumulation of scientific facts—to research—but that they should at the same time encourage and develop scientific men.

They should have much to do with the training of geologists in proper methods. It will not cost much, and it will look well, and the few efforts required by such encouragement must yield valuable results in the future. Geologic investigation should therefore, in so far as possible, aid and encourage instruction.

Work is often needed in the vicinity of colleges in order to have it available in instruction, and the national survey should see that this work is done—in other words it should coöperate with the professor in charge, giving what he needs, and obtaining in return such contributions as he can make to local geology.

Geologists are sometimes modest men. It is the duty of the national survey to look these modest men out and to encourage and help them and to make them feel that they are a part of the geological body of the country. It should see to it that there is no geological ground left uncultivated.

Coöperation.—If a cordial coöperation should be brought about between all the working geologists of the country there would be

more satisfactory progress all along the line. This is made necessary by the number of geologists in the country, by the country's vast area and by the conservation of energy and of funds.

Imagine a number of men working, a few under organized direction, but a large number independently, and with no responsibility to anyone, for the purpose of erecting a large edifice. Those who direct have in mind all the specifications; they know what kind of material is wanted and how much, and where it is needed. Those who bring and prepare this material use their best efforts—they labor in love and with the inspiring hope that they are contributing something to this great building. What must one's feelings be when he brings his contribution to find that it is in the wrong place, or that it is not wanted? Mistakes of the same sort are constantly being committed in geologic work, and in abundance too, all because we have no recognized directing head for the work done outside of the United States Geological Survey.

The bulk of geologic literature must yearly become greater, and unless it becomes at the same time better, we must expect a day to arrive when geologists may well stand appalled before it. Much of this literature is practically worthless; it is an encumbrance rather than a help to the progress of science, and we should feel grateful to any method that would deliver us and geology from an evil which is coming to be a more and more serious one.

In one of the states in which the United States Survey has been doing topographic work, an area of 3000 square miles that had already been surveyed had to be remapped by the state survey to meet its own demands. Here I think no one will have any difficulty in understanding the necessity of coöperation between the state and the national survey.

Take as another example the chemical analyses made for geologic purposes. The chemists of state and national survey have thrown upon them a vast amount of heterogeneous work, while but little or no time is left them for original investigations. A great many of their analyses are duplicated elsewhere, or may be duplicated in any number of laboratories, so that investigations that might otherwise have been possible are prevented, and both chemistry and geology are hindered.

The errors committed by geologists not connected with the surveys are mainly due to haste, or in other words to expression of opinion based upon too limited observations. But only limited observations

are possible to men of limited time for the work, and limited means to work with, a limited area to work in, limited acquaintance with-field geologists, and limited opportunities for publication.

There are many young geologists and men of but little experience—amateurs—whose efforts are not so directed as to be of as much service as they might be. They lack neither zeal nor means in many cases, but they do lack some one to guide their tottering footsteps. Their want of experience gives them but a restricted view of the field in which they are laboring. Their labors cannot therefore, unless directed by some one who has a sufficiently broad view of the whole field, be of any value to geology. Who will direct them? Or shall they go on piling higher their wasted energies, and find themselves, when they have come to the end, with the mortification of knowing that though they have worked hard and faithfully, they have in reality contributed nothing to the sum of human knowledge?

So our energies are not fully utilized; we are like a great system of machinery with here a bent shaft wasting the greater part of its energy in friction, there a broken belt that has stopped a useful machine, here a timber caught in the wheels and beating the walls and floors.

If we could have some sort of coöperation, a man at work upon a particular subject would have some assurance that his field of operations would be, within all reasonable limits, left to him. As matters now stand a geologist is often obliged to mount guard over his own grounds and in his own work to keep the unscrupulous camp-followers of science from walking off with and getting the credit for the results of his labors.

Coöperation would enable each one to concentrate his efforts upon that line of work or that investigation in which he is especially interested. As matters have gone heretofore no state survey, and no man on a state survey, has been able to take up any one subject in a systematic and thorough manner unless it has happened that some one group of facts has been available in his own state alone. Take any topic you may choose for a test and you will find this to be an invariable rule.

Do the best we may, there is not one of us who may not be benefited more or less by friendly criticism. And it is of great importance to the science that these criticisms be made before our results or observations are published. In this way we may avoid

adding to that vast talus of geologic trash beneath which the science of geology is buried more and more each year. Such criticism is not possible except under conditions that enable us to know the lay of the land with reference to other geologists and to what they have done and are doing.

It should be distinctly understood from the outset that such work is to be not subordination, but coördination and, above all, coöperation. The demands of scientific work do not require, and the conditions and peculiarities surrounding scientific ambition and devotion do not admit of the most successful and satisfactory work being done in a perfunctory manner.

I would not by any means destroy the autonomy of local societies or of independent workers not formally connected with the public surveys. Certain independence of thought and action is essential to scientific advancement, and friendly rivalry is not only not injurious but it is extremely helpful, and in many cases absolutely essential. But such an organization of geologists would have to allow and even encourage this independence. Every man should be held responsible for his own work and, in this way, made to retain the sense of personal responsibility.

This plan of coöperative action, in order to be successful, would require that in the work accomplished there should be the fullest recognition for each man's contribution. Workers in science will not be found willing to make of themselves parts of a great piece of machinery which entails the loss of their individuality. They must have the fullest credit for all they do. At the same time one must not try to get all the good he can without giving something in return.

I have no idea that a "perpetual motion" sort of a geological machine can be devised, or that any arrangement or adjustment of parts is possible which will entirely do away with friction.

It is scarcely possible that any device that can be made or suggested would be perfectly satisfactory, but it certainly is reasonable to expect that some system of coöperation can be devised and put into practical operation. If ever such operation should be brought about, several points must be kept in mind by us all.

There must be a certain amount of elasticity in any plan that may be adopted; for geological investigation, like any other investigation, leads us off on many unexpected tangents.

Subordination would have to be largely nominal, for those who

do the best and most work would have to take precedence of those who did not so well.

As much latitude as possible would have to be allowed individuality. Men are not like pieces of coal to be separated and classified by sizes or by specific gravity.

Administrative methods devised for scientific work, like those of diplomacy, are often a series of compromises, and good sense must make up for the defects of any system.

No plan of coöperation can succeed if we do not all take a broad and unselfish view of science and its functions; we must work for its advancement; and the idea of putting a caveat on this or that topic must be relegated to the dark ages of geologic science.

Men will be ready to coöperate with us the moment they are made to feel that their contributions are useful and are appreciated, and that they will not lie unattended for years in the hands of some one not impressed with the shortness of time and of human life.

In order to have coöperation each one must do, in addition to the direct objects of his work, what others want.

Local talent should be utilized. It would, in many cases, save a good deal that now goes to pay travelling expenses, to say nothing of the importance of keeping all the geologists of the country actively interested in geologic work.

A working geologist, if he works intelligently, must know and keep in mind what other people are doing; and he certainly cannot do this if he is working alone, and without any recognized relations to other geologists.

The direction of work. — Now if geologic work can be improved by being under the nominal direction of those best fitted to direct, where are we to find our directors? The men who have done most to popularize the science of geology in this country are our professorial geologists, and it is not unnatural that we should turn to them. But the teachers of a science are not necessarily the best directors of research, while they are probably in no case thoroughly conversant with the work being done by the various state surveys and by the national survey.

The direction of work over the whole country would be quite as impossible, or even more so, from the states.

The national survey, standing as it does at the head of all the geologic work done in the country, having the whole national domain as its field, and composed, as it is, of our best geologists and

having the most thorough organization, is, or should be, the natural head and director of all geological work in this country. I have no doubt that the national survey would be glad to help, in so far as it can, to unify and to give useful direction to this work.

I take this ground in the face of the statement of the distinguished Director of the United States Geological Survey who has said that, "all of this scientific research under national, state, and local patronage cannot be controlled by some central authority, as an army by its general, from the fact that scientific men, competent to pursue original research, are peculiarly averse to dictation and official management. Scientific men spurn authority, but seek for coördination."¹

The function of a director or of a superior, in science at least, is not, to be sure, that of a commander ordering here and there men who must simply obey, who must have no independent opinions or plans of their own; he must rather be a helper, a man to encourage, to suggest, to fire with enthusiasm those under him and to unify the work of the organization of which he is the head. Scientific men do not spurn authority if there is any reason for it, and as a proof of it we may cite the United States Geological Survey itself, as well as all the state geological surveys in this country, or for that matter, in the world. The members of all these surveys submit to all reasonable authority, but they are also put upon congenial work, and they are permitted to do that work pretty much in their own way. Now why can there not be an organization of all geologists more or less similar to this?

We may disabuse our minds of the thought that there is a probability or even a possibility of the government monopolizing geology. It cannot do it; geology belongs to the geologists, whether the government helps carry on geologic investigations or not.

Conclusions.—My conclusions are:—

First, that the great and valuable contributions to geologic knowledge must be made by our official surveys, for they alone have the means for producing them—for gathering the facts, giving the necessary time to philosophical thought and discussion, for furnishing the necessary illustrations and for making and distributing the publications.

¹ Testimony of Maj. J. W. Powell; Organization of Certain Bureaus, Mis. Doc. No. 82, 49th Congress, 1st Session, 1884-5, p. 178.

Second, that economic problems should be left, in so far as it is possible, to the state surveys, while the national survey should deal with those requiring larger means and a wider range of observations.

Third, that all the working geologists of the country should be brought into official or quasi-official relations with the state and national surveys and their efforts and skill thus utilized.

I am free to admit, however, that no plan of coöperation can be devised that will work to the complete satisfaction of everybody. We sometimes have men to deal with who are not amenable to either law or reason.

In his presidential address before the American Association at Cleveland, Professor Langley compared the advance made by scientific men in their search after truth to that of a pack of hounds following a trail. Permit me to carry this simile still further. Hounds understand that it is their business to follow the game, and, when left to their own instincts and wishes, they will follow it. Now imagine a bull-dog seized with the ambition to become a hunter and joining the pack of hounds. Everyone knows that the bull-dog will, in spite of anything that can be done, have a fight with half a dozen, or, more likely, with the whole pack of hounds, by the time the chase is well under way.

It is not a pleasing reflection to remember that the great search after truth in which every genuine man of science is engaged, heart and soul, is often interrupted in this same fashion by the pugnacious disposition of some companion.

Let me recapitulate some of the benefits to be derived from voluntary and cordial coöperation between all geologists and all geological organizations in this country.

I. Geologic research being under the nominal directions of the leading investigators would be so conducted as to be of the greatest utility to the largest number.

II. When a piece of work was done by one it would be done for all, and duplications by state surveys and by individuals and the consequent waste of energy, time and money would cease.

III. The functions and fields of official organizations being better defined, state and national surveys and individuals could so direct their efforts as to serve the purposes of others without neglecting their own immediate aims, and without infringing upon each other's ground.

IV. National and state surveys would be strengthened and local organizations and individual efforts encouraged.

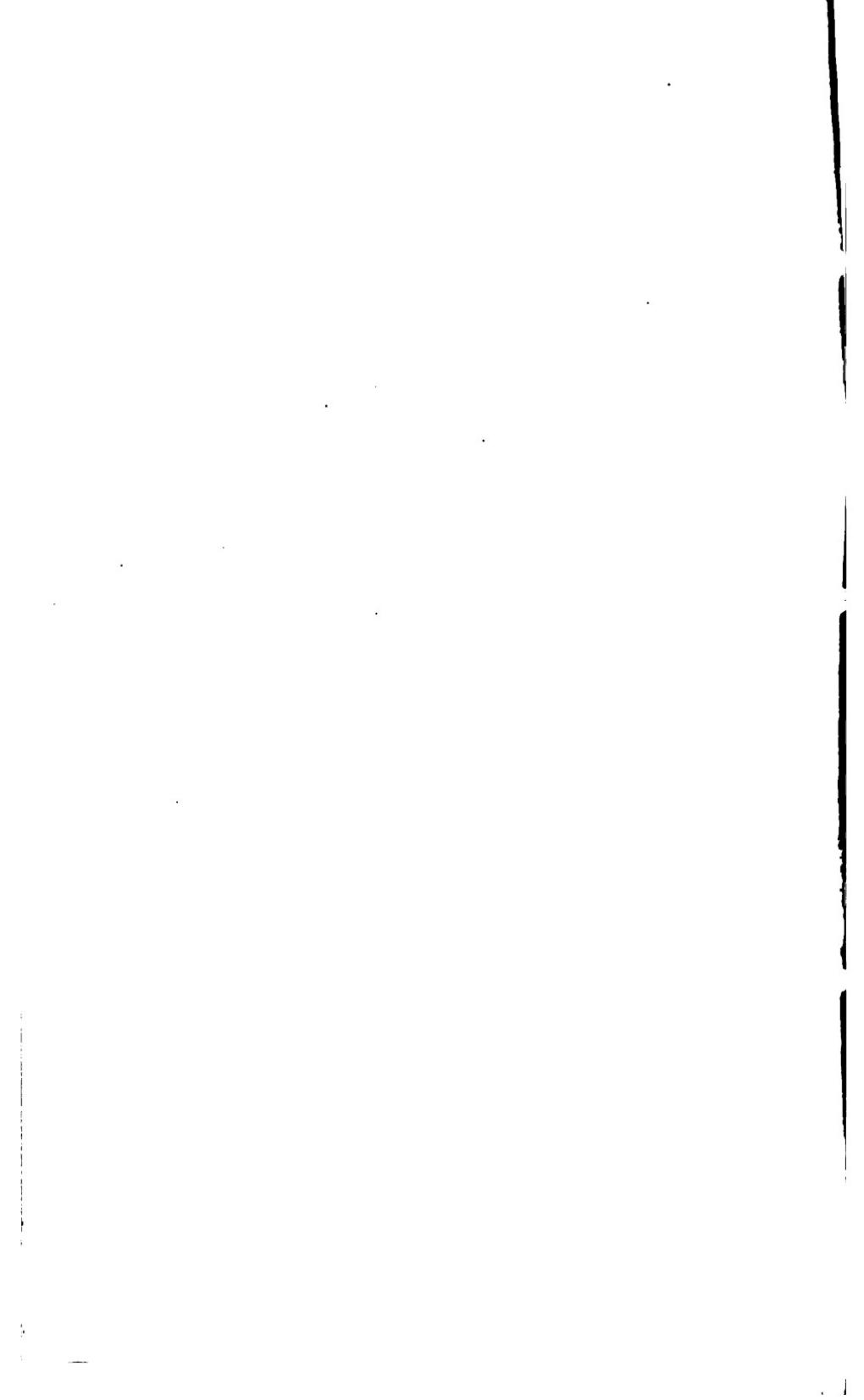
V. It would give us a better geologic literature, better instruction, better geologists and more thorough specialists.

VI. And, finally, we trust, it would put a stop to those oracles who are so ready to prophesy in the name of science.

This ideal state of affairs may never be brought about, but it is none the less desirable that we should aim at it; for the more nearly we approximate to it the more rapid will be the progress of science, and the progress of science is the progress of civilization.

To paraphrase a recent utterance of Bishop Potter, "It would be a monstrous conception of science if any one of us were to esteem it only as a selfish weapon with which he was to carve his way to personal fame and fortune."¹ It has often been used for just that purpose, but higher ideals will give us nobler motives.

¹Phi Beta Kappa Address at Harvard, 1890.



PAPERS READ.

ON THE BIOLOGICAL AND GEOLOGICAL SIGNIFICANCE OF CLOSELY SIMILAR FOSSIL FORMS. By Prof. CHARLES A. WHITE, U. S. Geological Survey, Washington, D. C.

IN the study of the fossil remains of organic forms two leading objects are to be attained by investigators, one of which relates to the classification of geological formations, and the other to historical biology. It is plain that both these objects ought to be kept in view by those who engage in such studies, but it is equally plain to those who are familiar with paleontological literature that the relative importance of each is differently estimated by different investigators, and also that the writings of one and the same author are sometimes found to favor one, and sometimes the other, of these objects. Such a difference in an author's method of treating similar subjects does not, however, necessarily indicate inconsistency on his part because, in many cases at least, it is evidently due to a difference in the character and scope of his different writings rather than to conflicting views in his own mind.

For example, when one who relies upon both biological and physical data is engaged upon field work, the prime object of which is the elucidation of the structural geology of a given region, he naturally treats the paleontology of the formations with which he has to deal in such a way as to best aid him in their characterization and classification. But if the same person should engage in a paleontological work having no immediate reference to structural geology he would be more inclined to treat his subject upon a purely biological basis.

The circumstances, however, which attend the labors of a geologist, who is also a paleontologist, are not always so clearly defined as those just referred to, and it is sometimes difficult for him to decide what course he ought to pursue with reference to certain of the fossil faunas which from time to time come to his hands. It is especially difficult for him to decide how he ought to treat certain forms among those faunas that seem to have a great geographical, or even a world-wide, distribution as well as an extremely great chronological range. He finds it quite as difficult also to decide what course he ought to pursue with reference to those fossil forms which sometimes are found to so closely resemble living species that he cannot diagnose them in materially different terms.

The forms to which this reference is specially made all belong to the

mollusca, and far the greater part of them are bivalves. It is significant also that the greater part of them are inomomyarians, and that the heteromyarians come next as to numbers. A few of them are dimyarian forms, but most of these are denizens of fresh and brackish waters, while the former are all of marine habitat. The few gasteropods that need be referred to in this connection are palustral and land pulmonates.

My meaning with regard to the doubts which different authors may entertain concerning the proper paleontological treatment of these forms will be better understood if I refer to a few cases that are recorded in my own and other publications.

Ostrea diluviana Linnæus, is a well known European Cretaceous form of the Turonian epoch.¹ A form reported to have come from the New Jersey Upper Cretaceous was published by Coquand² under the name of *O. barrandei*, but which is so nearly like *O. diluviana*, that if specimens of each were placed together in a collection no one would be likely to question their specific identity. I have published a form from Texas³ which I referred to *O. diluviana*, and another from California⁴ which does not greatly differ from it, but to which I gave the name of *O. dilleri*. The latter comes from the Upper Cretaceous Chico Group of California and the other from the Comanche series of the Texan Lower Cretaceous.

Now here are three North American forms that differ from one another and from *O. diluviana* no more than may reasonably be attributed to interspecific variation, all of which many paleontologists would not hesitate to refer to the European *O. diluviana*, notwithstanding its occurrence on a distant continent. Moreover, one of these three North American forms, as already intimated, occurs in a widely different horizon of the Cretaceous system from that of the two others, and the localities at which those two forms occur are 2,500 miles apart. Besides this, not a single one of the species which constitute the fauna to which one of these forms belongs has ever been found associated with either of the others. That is, the California, New Jersey and Texan faunas are wholly different from one another if we except these seemingly identical Ostreid forms.

Ostrea blackii White,⁵ so much resembles certain varietal specimens of *O. semiplana* Sowerby,⁶ that some paleontologists would doubtless refer the former to the latter species; but the former comes from the Lower Cretaceous of Texas and the latter from the Upper Chalk of England. Besides this, all the other members of the Texan fauna are different from those of the English fauna.

Exogyra texana Roemer,⁷ from the Comanche series of Texas is very closely like *E. bousingaultii* d'Orbigny,⁸ yet the latter is from the lower

¹ See for example Paleont. Francaise. Cret., Vol. III, p. 728, pl. 480.

² Monog. du Gen. Ostrea, p. 47, pl. XII, figs. 1-4.

³ Fourth Ann. Report U. S. Geol. Survey, p. 285, pl. XL, fig. 1, and XLI, 1, 2.

⁴ Bull. U. S. Geol. Survey, No. 51, p. 14, pls. 1 and 2.

⁵ Fourth Ann. Rep. U. S. Geol. Survey, p. 292, pl. XLV, fig. 1, and pl. XLVI, fig. 2.

⁶ See Sowerby's Min. Conch. (Agassiz), p. 514.

⁷ Kreidebildungen von Texas, p. 69, pl. X, figs. 1, a, b, c, d, e.

⁸ Paleont. Francaise, Vol. III, Cret., p. 702, pl. 468.

Neocomian of Europe, while the former is from a higher, but still a Lower Cretaceous, horizon in Texas, where it is associated with a fauna that is quite unlike that with which *O. housinguaultii* is associated.

At certain localities in the Laramie group I have found great numbers of the shells of *Ostrea wyomingensis* Meek, none of which could be specifically diagnosed as different from the living *O. virginica* of our Atlantic coast; and yet the Laramic group is referred by many authors to the Cretaceous. Besides this we cannot admit that the Atlantic form *O. virginica* was genetically derived from *O. wyomingensis* because the latter form was a denizen of an inland sea and became extinct by the destruction of that sea in consequence of continental elevation which occurred not later than the early part of the Eocene period. In the marine Cretaceous formations that underlie the Laramic, Ostreid remains are also found which quite as closely resemble *O. Virginica* as do those of *O. Wyomingensis*.¹

A large collection of fossils obtained from strata in the province of Sergipe, Brazil, which I referred to the Neocomian, contains an Ostreid form which is so closely like the type specimens of *O. palmetta* Sowerby,² that I provisionally gave it the same name, although the latter form is from the English Jurassic.³

In the same collection are specimens of a *Pteria* which is so closely like *P. linguiformis* Shumard,⁴ that I provisionally published it under the same name, although the latter is from the Upper Cretaceous of North America,⁵ associated with a wholly different molluscan fauna.

In the Brazilian collection that has been referred to there are several other species which I treated as respectively identical with certain European, Indian and North American species, the original specimens of which came from various Cretaceous horizons and the faunal associates of which are different from those of the Brazilian forms.

In a small fresh-water fauna from Jurassic strata in Colorado there are certain forms that are respectively very much like living species,⁶ two of which may be specially mentioned. One of these, *Unio felchii* White, is so closely like *U. gibbosus* Barnes, that it would be difficult to diagnose its features in different terms. The other, *Limnaea atavuncula* White, is extremely like the smaller and more slender examples of *L. decolorata* Say, a well-known living species. Besides this, the whole fauna has a modern aspect which contrasts strongly with the ancient character of the dinosaurian remains which are found in immediately underlying and overlying strata.

Similar examples might be mentioned of other species belonging to other genera and families, but these are suggestive of more interesting inquiries than can now be considered. Among the questions that naturally rise

¹ See for example U. S. Geol. Expl. 40th parallel, vol. 4, pl. 15, figs. 10 a, b, c.

² Archivos do Mus. Nacional, Vol. VII, p. 29, pl. 7, figs. 3, 4, 5.

³ Sowerby, Min. Conch. (Agassiz), p. 164, pl. 3, figs. 3, 4.

⁴ Archivos do Mus. Nacional, Vol. VII, p. 50.

⁵ See Vol. IX, U. S. Geol. Survey Terr., p. 32, pl. 16, fig. 1, a, b.

⁶ Bull. U. S. Geol. Survey, No. 29, pp. 9-24, pls. 1-4.

in the mind of every paleontologist who considers such facts as these, two are especially prominent.

First, were the species, to which reference has been made, capable, above all others, of world-wide distribution and of persistence through long periods of geological time? Were their vitality and their integrity of specific characteristics such that colonies of each form, unaccompanied by any of its originally associated species could have migrated thousands of miles from one fauna to an entirely different one, and become as flourishing a member of the latter as of the former fauna; and could this specific integrity and these migrations have been continued in time until all its originally associated species became extinct?

Second, have there been in different parts of the world, and at different geological epochs, certain species which assumed the visible characteristics of certain others that existed in other parts of the world and during other epochs, but which were really distinct from one another, or that did not originate in the same direct line of genetic descent?

Those paleontologists who in their publications invariably give the same specific name to forms that present closely similar features, regardless of their faunal associates, or of their geographical and geological position, must necessarily accept the affirmative of the first proposition, but they, as well as every other thoughtful naturalist, must admit that the second proposition deserves careful consideration. Those geologists who make constant use of paleontology in their investigations will often be inclined to a practice which, while they may not formally accept the second of those propositions, really leads them to a partial recognition of it.

This practice I am inclined to approve so far as it is applied to the classification and characterization of geological formations. That is, when, upon investigation, a given formation is found to bear a fossil fauna the component members of which, with such exceptions as have been referred to, are all unlike those of any other known fauna, I think it admissible to treat the whole fauna as new, and to give a new name to each species.

For example, I now think that Coquand did well to give the name *Ostrea barrandei* to his New Jersey form, and that it would have been well if I had given a new name to the Texan form which I referred to *O. diluviana*. I think also that Professor Roemer did well to give a new name to the Texan *Exogyra* which so closely resembles *E. bousingaultii*, because the whole Texan fauna is unlike that with which the European species is associated, and because the two forms belong to different geological horizons. Again I perhaps ought to have given new names to all or nearly all, those Brazilian forms to which I have referred; and I should probably have done so if I had been making a personal field study of the formation from which the fossils came, and of its relation to overlying and underlying formations. Still, one may well deny the propriety of giving the name *Ostrea Virginica* to the Cretaceous forms that so much resemble that living one.

I think that such methods of paleontological study as I have indicated, when undertaken in connection with the investigation of geological forma-

tions with a view to their continental taxonomy, and to their ultimate correlation with formations of other continents, will give the best and most direct results, especially as such methods would not prevent or retard the subsequent rectification of the results of such studies upon a purely biological basis. That is, I think that such a practice among North American geologists will more speedily give us a comprehensive knowledge of our formations than would one in which biological ideas are predominant, especially if those ideas are influenced by preconceived standards.

The objection that such a practice would tend to load paleontological nomenclature with useless synonyms is worthy of consideration, but I am disposed to regard that as a comparatively small evil under the circumstances that I have indicated.

THE AMOUNT OF NATURAL GAS USED IN GLASS MANUFACTURE. By Prof.
EDWARD ORTON, Columbus, Ohio.

[ABSTRACT.]

NATURAL gas is so well adapted to glass manufacture that when it can be obtained at all, it becomes a necessity. The centers of glass production in the country have been largely shifted within the last five years to follow the developments of gas, especially in the new fields of Ohio and Indiana. There are now in these gas fields six hundred glass pots, comprising more than half of the table ware and pressed ware manufacture of the United States.

Until very recently, there has been no determination of the amount of gas consumed by a glass pot in a day's run. The first published figures are given in the paper herewith presented.

By an ingenious adaption of Pitot's tube, Prof. S. W. Robinson of Columbus, Ohio, has constructed a gauge, applicable to any service pipe of steam boiler, furnace, kiln or rolling mill, under any pressure. The result of measurements taken on most of the glass factories of northwestern Ohio during the last summer has established the fact that a glass pot in a window or bottle works consumes in twenty-four hours an average of 70,000 cubic feet of gas and that a table ware glass pot requires a little less than 50,000 cubic feet per day. The 600 pots of the new gas fields are consuming about 35,000,000 cubic feet of natural gas every day and in the year's run of 300 days, 10,500,000,000 cubic feet.

It is not in the nature of things that this supply can be long maintained and it is unfortunate that so enormous a consumption should have been forced upon the gas fields.

THE FORMATIONS AND ARTESIAN WELLS OF MEMPHIS, TENN. By Prof.
JAS. M. SAFFORD, Nashville, Tenn.

[ABSTRACT.]

In boring the Artesian wells of Memphis, several formations were penetrated as follows:

1. The *Loess*, 25 feet thick; maximum thickness within the limits of the city, 60 feet.
2. The *Gravel and Sand*, 20 to 25 feet; maximum thickness within the city limits, 60 feet. Hilgard's Orange Sand.
3. The "*Impervious Clay*," 145 feet, the cover to the water-bearing sand below.
4. The great *water-bearing sand* (*Lagrange*), 800 feet thick.

The thickness of the latter was found by a test well passing through it and sunk to a depth of 1156 feet below high water of the Mississippi river. The deepest material found was sand with a few beds of clay.

Upon penetrating the clay cover and entering the water-bearing sand, an abundant flow of clear, sparkling water follows, blessing Memphis with a supply little dreamed of a few years ago.

[The paper is published in full in the *Tennessee State Board of Health Bulletin*, Vol v, No. 7, pp. 98-106, Nashville, Tennessee, Feb. 20, 1890.]

THE COLUMBIA FORMATION IN THE MISSISSIPPI EMBAYMENT. By W J
MCGEE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE Columbia formation was defined and described in a communication before the A. A. A. S. at New York, in 1888. It is a series of clays, sands, loams, gravel beds, etc., laid down during an extensive submergence of the coastal regions of the United States coeval with the first ice invasion of the Pleistocene. In southeastern United States, the Columbia is represented by the widespread coast sands of the lowlands; in Alabama and eastern Mississippi it is represented by similar sand deposits over the lower uplands, and by "second bottom" loams and clays along the rivers. During the two months preceding this meeting, the formation has been traced into the Mississippi embayment, and found to undergo remarkable development under the influence of the great river. It reaches a thickness of several hundred feet, and rises upon the uplands to the eastward at least 500 or 600 feet above tide level. At the same time it differentiates into several members, which are fairly constant and clearly defined though they merge at every junction and evidently represent continuous deposition under varying local conditions. The principal members are: 1, yellow or brown loam; 2, loess; 3, stratified sand and gravel (a part of the orange

sand of Hilgard); 4, stratified and often finely laminated blue or black clay, sometimes containing vegetal accumulations, stumps and logs, and even beds of lignite—the Port Hudson of Hilgard. The identification of the members has been effected by study not only along a meridional line skirting the Mississippi, but also along a dozen transverse lines extending from the margin of the deposits to their axis about the river bluffs and bottom.

AN OLD CHANNEL OF THE NIAGARA RIVER. By J. T. SCOVELL, Terre Haute, Ind.

[ABSTRACT.]

THE Niagara river is interesting to geologists because of its supposed relations to the glacier, and because many hope from the study of the work of this river to determine a unit of geological time.

It is supposed that the waters of Lake Erie formerly flowed into Lake Ontario by a channel some miles west of their present course, and that the retreating glacier so obstructed this old channel that the waters were compelled to take a new course forming the Niagara river. In estimating the time that has elapsed since the retreat of the glacier, geologists at first varied from 35,000 years to 100,000 years.

The old channel discovered by Professor Hall about 1841, more careful measurements, and other facts brought out by Dr. Pohlman and others and discussed by the section at Buffalo, enabled geologists to reduce their time estimates to from 3000 years to 10,000 years.

An examination of the bank of the river on the Canadian side of the rapids shows it to be composed of boulder clay, sand and gravel, and that this earthy material conforms to the rapid slope of the rocky bed of the river. This bank is from 40 feet to 90 feet high and forms a portion of a continuous mass, principally of sand and gravel, that extends from the river northward about five miles to the escarpment, about two miles west of the river. At this place is located the little village of St. Davids. Wells in this sand belt, from 60 feet to 100 feet deep, do not reach the rock, while wells in the clay on either side reach rock at a depth of from 7 feet to 20 feet. These facts seem to indicate an old channel. The eastern bank is quite distinct at the falls and at St. Davids. By an examination of the wells between the escarpment and the lake the channel can be traced into the river about two and a half miles above its mouth. At this place there is no rock in the river bank and deep wells do not reach the rock, while on either side the rock is covered by only a thin layer of soil. There is so much clay along the sides of this channel, that it seems as if it had been excavated, then filled with clay, which later was partially excavated and its place filled with sand and gravel.

The existence of this old channel seems to warrant us in increasing our estimate of the time that has elapsed since the primary advent of the gla-

clear and in lessening our estimate of the age of the present river. This channel also shows that there has been at least two and perhaps three, advances of the glacier over that region.

PRESERVATION OF GLACIATED ROCKS. By HOMER T. FULLER, Worcester, Mass.

[ABSTRACT.]

THE weathering of the rocks in all latitudes is well known. This weathering in northern latitudes often obliterates glacial scratchings and groovings. The attention of the writer has been called to the remarkably perfect preservation of glaciation in the hydro-mica schists of what Professor Hitchcock has called the Merrimac group of rocks in central Massachusetts. The best illustrations are seen at Clinton a little way out on the Lancaster road, and on Oak Hill at Worcester. This hill has been scored, planed or scratched over nearly its whole surface. The rock has a dip of 65°, is comparatively soft, and yet the polished grooves are apparently as smooth to-day as when first made. The cause of this seems to be three-fold: (1) a light covering of earth which nourishes only mosses and low shrubbery; (2) the great dip of the whole mass of rock; and (3) the enormous pressure of the moving glacier which bent the mica scales to an horizontal and cemented them together, making thus a rock-roof almost impervious to water.

On another lower ridge of the city the same rock is, for the most part, covered with earth to the depth of two to six or more feet. Here, heavy forests have grown and decayed. The rock for eight or ten feet below is so disintegrated that it easily crumbles between the fingers and hence all glacial scorings are obliterated. Yet even on a slope of this hill where only a few inches of soil mantle the ledge, glaciation is distinctly seen.

The comparison makes it clearly evident that in these localities organic acids derived from the decay of vegetation and filtering through the soil beyond the point of much natural evaporation are the chief agents in rock decomposition. Shallow soil preserves rock best; deep soil, unless clay be a constituent, facilitates disintegration, while bare crystalline rock weathers slowly and superficially.

WHAT CONSTITUTES THE TAUCONIC MOUNTAINS? By Prof. N. H. WINECHELL, Minneapolis, Minn.

[ABSTRACT.]

THIS paper calls attention to the definitions of the Taconic mountains by Fitch, Hitchcock, Emmons and Dana, and shows their position on an outline map and by names of the principal peaks.

It then shows that, according to the descriptions of both Dana and Walcott, these mountains are included in the area that has been found to contain the primordial fauna, and that the great slate belt (or "magnesian slate") which Mr. Walcott has colored as Georgia formation on his late map, composes the range throughout Vermont, instead of the "Hudson terrane."

TOPOGRAPHIC FEATURES OF ARKANSAS MARBLE. By T. C. HOPKINS,
Geological Survey of Arkansas, Little Rock, Ark.

[ABSTRACT.]

THE marble is found in North Arkansas by which is meant the country north of the Boston and Blue mountains. These mountains extend from the White river in Independence county westward. This region is drained by the White river and its multifold branches. The main body of the marble lies on the south side of the river, except in Independence county and Izard county where it is on the north side. The outcrop has been traced and carefully mapped in Independence, Izard, Stone, Searcy, Baxter, Marion, Boone and Newton counties; it is known to be in Madison and Carroll counties and possibly extends to the state line and beyond.

The outcrop forms, for the most part, an excessively irregular and winding escarpment north of the Boston mountains which form the southern boundary of what was once a rugged plain covering these northern counties. This plain is now indented by the White river and its almost innumerable ramifying branches. It is on the cliffs and steep rocky hill-sides of these gorges that the marble is found.

The marble is overlaid by a heavy bed of chert in which is contained a bed of gray crystalline limestone (which furnishes nice marble in places) which varies greatly in thickness, in some places limited to a few inches of intercalary limestone; in others almost wholly replaced by the chert. This chert is overlain by a soft but very durable yellow sandstone. These two rocks, the chert and the sandstone, apparently being the most durable in the region, form the tops of nearly all the hills. The marble is underlaid by a heavy bed of blue limestone in the eastern part of this region which thins toward the west until it is finally replaced by a massive, white, saccharoidal sandstone, which in turn is underlain by beds of magnesian limestone, siliceous limestone, sandstone and chert.

In the eastern part of this region the marble bed is much heavier than in the western part and consequently has greater influence on the topography. It may be distinguished on any good topographical map of this part of the country by its *relatively* straight water courses and steep hill-sides. It takes both these conditions to distinguish it, as the overlying rocks have straight water-courses, but not steep slopes, the underlying rocks have very steep slopes but also very crooked water-courses. To the west the marble bed thins and lies nearer the tops of the hills and

does not manifest its presence so strongly, but generally may be known from the greater complexity of the water-courses. The streams that head in the marble will be much more ramifying than those which head in any other rock. The peculiarity noticed about the eastern part of the bed may be seen here by studying a map of the entire region; in which it will be seen that the general course of many of the streams will be nearly straight, presumably given them when they flowed through a marble channel, their present windings being formed after they had cut their way into the lower rocks.

[A detailed description of this region will be given in the monograph on marbles and limestone, which will form volume iv of the Report of the Geological Survey of Arkansas for 1890.]

THE NOVACULITES OF ARKANSAS. By LEON S. GRISWOLD, Geological Survey of Arkansas, Little Rock, Ark.

[ABSTRACT.]

SINCE early in this century, the Arkansas novaculites have been known commercially as very excellent whetstones both in this country and abroad. Little was known, however, of their mode of occurrence, until Professor Owen's geological reconnaissance of Arkansas was made in 1858 and '59. The stone composing the mountains of novaculite, which were then found about Hot Springs, was regarded by him as a metamorphic product from sandstones by means of hot spring action.

A more thorough examination leads in the main to a different conclusion, though it is possible that some of the novaculites are altered sandstones. The external resemblance to chert immediately strikes one on examining the rocks superficially, and this resemblance is fully carried out in the microscopic examination and in chemical analyses. The rock consists of 98 to 99 % silica, as do some cherts, with similar proportions of iron and alumina, lime, salts, and volatile matter. Microscopically the novaculites show a dense ground mass of very fine irregular grains of silica. Cherts show the same finely granular ground mass, but have generally a greater or less proportion of the silica in the chalcedonic form, a form not found in the novaculites. In this one point then the Arkansas novaculites differ from cherts.

The abrading quality of the stone is due to scratching by the minute irregular grains of the ground mass. One variety of the stone, known commercially as "Washita," has a more rapid sharpening quality due to a multitude of minute rhombohedral cavities having sharp cutting edges. The form of the cavity tells clearly of the former existence of calcite in the stone, and this theory is corroborated by the presence of calcite rhombs entire in some specimens. These rhombs have also been noted in cherts. About the rhomb the silica grains are packed closely, often showing like brick work; and the sharp edges thus formed give the

Washita stone a more rapid cutting power. In the best Washita stone there are in the neighborhood of 8,000,000 rhombohedral cavities to the cubic inch.

Most chert beds occur interstratified with limestones; the Arkansas novaculites have limestones associated with them only occasionally and in thin beds. Shales and quartzose sandstones are almost exclusively the associated rocks, the shales occurring often in thin beds between the novaculite strata and grading through flinty shale into translucent novaculite.

A typical section of the rocks of the novaculite area of Arkansas is as follows:

	Feet.
1. Gray, red, yellow, and black shales with some sandy strata,	800
2. Quartzose sandstones with some shales,	400
3. Black flinty novaculites,	300
4. White or light-colored novaculites,	100
5. Black and gray flinty novaculites, with shales,	100
6. Massive white novaculites (forming ridges),	250
7. Gray, yellow and red shales,	300
8. Flinty shales,	200
9. Black graptolite bearing shales,	150
10. Limestones,	50
11. Quartzose sandstones,	600
12. Limestones,	100
 Total,	 3350

The graptolites of the black shales underlying the novaculites have been the only means of locating the strata with reference to the established horizons. Specimens of these graptolites have been placed by Dr. H. S. Williams in the upper part of the Lower Silurian.

The easternmost locality at which the novaculite strata have been observed is a few miles west of Little Rock. From here the trend of the formation is somewhat south of west extending into the Indian Territory, a distance of 125 miles or more. In width the system is at times represented by a single ridge a half a mile wide, while at others its folds cover a belt fifteen and even twenty miles wide. The novaculites of Arkansas occur in several geographical groups. In general, the system is essentially one great anticline with a syncline running along its back, thus dividing it into two parts, the south one of which is again divided in two by a north-south depression. The great northern anticline starts just west of Little Rock and ends a few miles east of the Indian Territory line. The smaller anticlines lie on the south side of the great one and are practically joined to it by smaller anticlinal ridges. The structure is simple when worked out in detail and resembles somewhat that of Pennsylvania though much more sharply jammed, the anticlinal noses plunging very steeply with axes even vertical. Since the novaculites are the hard strata controlling the topography, the eye soon learns to detect a change in the

structure by the height and physiography of the ridges and peaks. Thus, whenever the thickness of the novaculites is doubled, as it is in sharply folded anticlines and synclines, high peaks result. Even the two varieties of peaks can generally be distinguished; for the anticlinal peak will have a slope off its nose of 10-15°, while the slope of the synclinal spoon is 30° or more. Knowing these facts an observer can read the structure for miles around from any high peak. The extent and character of the folding are shown by a profile section across the axes of the folds. Such a section, now 8.4 miles long, was originally 14.1 miles in length.

[The novaculites are reported on in full in one of the volumes of the Report of the Geological Survey of Arkansas for 1890.]

THE ORIGIN OF THE MANGANESE ORES OF NORTHERN ARKANSAS, AND ITS
EFFECT ON THE ASSOCIATED STRATA. By R. A. F. PENROSK, JR.,
Geological Survey of Arkansas, Little Rock, Ark.

[ABSTRACT.]

I WISH TO SAY ONLY A FEW WORDS ON THE MODE OF ORIGIN OF THE MANGANESE ORES OF NORTHERN ARKANSAS, AND THE EFFECT THAT THIS ORIGIN HAS HAD ON THE ASSOCIATED STRATA. THE ORES, AS FOUND NOW, ARE IN THE FORM OF IRREGULAR FRAGMENTS AND NODULES OF VARIOUS OXIDES OF MANGANESE IMBEDDED IN A RED CLAY. BOTH THE ORE AND THE CLAY ARE THE RESIDUAL PRODUCTS OF THE DECOMPOSITION OF A BED OF CRYSTALLINE PALEOZOIC LIMESTONE. THE EXACT HORIZON OF THIS BED HAS NOT YET BEEN DETERMINED, BUT ITS FOSSILS ARE BEING STUDIED BY PROF. H. S. WILLIAMS.

THE ORE ORIGINALLY OCCURRED AS NODULES OF OXIDE SCATTERED ALONG THE PLAINS OF BEDDING OF THIS ROCK, OR AS SERIES OF CONNECTED AND INTERBEDDED LENSES. VERY OFTEN, WHERE THE ROCK HAS NOT BEEN ENTIRELY DECOMPOSED, THE ORE CAN YET BE SEEN IN THESE POSITIONS. THE MANGANESE IS NOT OF UNIVERSAL DISTRIBUTION THROUGHOUT THE LIMESTONE; IT OCCURS ONLY LOCALLY AND IN ISOLATED AREAS. IN THE REGION NORTH OF BATESVILLE, ARK., MANGANESE CHARACTERIZES THE LIMESTONE OVER AN AREA OF ALMOST A HUNDRED SQUARE MILES. BEYOND THESE LIMITS, THE SAME ROCK IS FOUND UNDERLYING A VERY LARGE TERRITORY, BUT IT RARELY CONTAINS AN APPRECIABLE QUANTITY OF MANGANESE ORE. A FEW SMALL ORE-BEARING DISTRICTS HAVE BEEN FOUND ELSEWHERE, BUT THEY ARE OF VERY LIMITED EXTENT.

IT SEEMS PROBABLE THAT THE ORE WAS ORIGINALLY LAID DOWN IN THE FORM OF CARBONATE OF MANGANESE DURING THE DEPOSITION OF THE LIMESTONE, AND THAT SUBSEQUENTLY, WHILE STILL IN THE ROCK, IT WAS CONVERTED TO OXIDE. IT IS POSSIBLE THAT THIS CHEMICAL CHANGE TOOK PLACE AFTER THE ORE HAD BEEN DEPOSITED ON THE SEA FLOOR, AND BEFORE IT WAS COVERED UP BY A FURTHER DEPOSITION OF LIMESTONE. LATER DECOMPOSITION OF THE LIMESTONE HAS BROUGHT THE ORE INTO ITS PRESENT POSITION IN THE RESIDUAL CLAY.

SUCH A MODE OF ORIGIN IS VERY MUCH LIKE THAT WHICH PROBABLY TOOK PLACE

in the case of the manganese ores of the Appalachian Mountains. The principal difference is that, in the case of the Appalachian ores, the enclosing rocks are usually shales or limy shales, and sometimes cherts.

In the Batesville region, the ore-bearing limestone, where it is seen in an undecomposed state, is sometimes over a hundred and fifty feet thick. This bed is overlain by a chert bed reaching a maximum thickness of about one hundred and fifty feet; and it is underlain by a bed of blue limestone of two hundred and fifty feet in maximum thickness. When the manganese-bearing limestone has not undergone decomposition, both it and its overlying and underlying strata are almost horizontal, or dip off gently to the south or southwest, and no considerable disturbances are anywhere observable.

In many places, however, a large part or the whole of the manganese-bearing limestone has been decomposed, and the residual clay and the ore either overlie the remains of the original limestone or, when this has been removed, come into direct contact with the underlying blue limestone. The decomposition of the manganese-bearing limestone has taken place even where it was covered by chert. In such cases the chert, also, has undergone considerable disintegration, but at a much slower rate than the limestone. The result of this unequal decomposition is that we frequently find the whole of the manganese-bearing limestone leached away and over one-half the chert bed left, overlying the residual products of the former. In this operation, the chert has suffered considerable displacement from its original position; the thickness of the residual product rarely exceeds a fifth part of the thickness of the rock of which it once formed a part, though in some cases it reaches over half the thickness of that bed; such an occurrence, however, is exceptional. It has already been stated that the maximum thickness of the manganese-bearing limestone is over one hundred and fifty feet, and therefore the chert in many places has suffered a fall of over one hundred feet. The fall was, of course, very gradual, and progressed only at the same slow rate as the limestone decomposed. The effect on the chert, however, has been very marked. That bed has not only been very much broken, but has been disturbed in such a manner as to give rise to a series of small anticlines and synclines, often dipping off at angles of 45° to 60° . The chert has not assumed these forms by folding; it has been greatly shattered and has adapted itself to its present position by a series of fractures alone; yet the continuity of its different parts can be clearly made out. Though it is a hard rock it is very brittle, and when the underlying bed is removed, it acts very much as would a plate of glass if pressed down over an uneven surface. It is to this brittle quality that it owes its power to adapt itself to the undulations of the underlying surface. In such cases, the chert has been eroded down to a thickness of thirty to sixty feet.

A very common result of this disturbance is a cone-shaped hill with the chert dipping off on all sides. In the interior of such a hill there is often found a conical mass of the original manganese-bearing limestone. This is usually separated from the chert by a variable thickness of residual clay

and manganese ore; and it represents a part of the limestone bed which has so far escaped decomposition. This irregular decomposition is very marked in the manganese-bearing limestone, and to it are due almost all the disturbances observed in the chert. Where a knob of limestone has withstood erosion, a small chert-covered hill is the result, and between two such hills the chert lies as a synclinal blanket. Sometimes, later decomposition has removed this knob, and the chert has suffered a still greater fall. Below the disturbed chert, an almost horizontal position is observed in the remains of the manganese-bearing limestone, or in the still lower blue limestone; thus proving that the disturbances in the chert have not been produced by lateral pressure.

In many cases, decomposition has gone further than the destruction of the manganese-bearing limestone, and has even attacked the underlying blue limestone. As a result, we frequently find deep holes running down into this bed for a depth of thirty to forty feet, and filled with residual products. A very common occurrence, in places where this further decomposition has gone on, is a small dome-shaped hill rising fifty to a hundred feet above the surrounding level, and capped by a small knob of chert. On the slopes can be seen the red residual clay, and at the base the blue limestone. In many places, a bed of sandstone, which underlies the blue limestone, is also exposed. The chert on the slopes of the hills, with the exception of a few scattered fragments, has been entirely removed.

The series of sections on the wall shows the successive stages of decomposition in the manganese-bearing limestone. The first represents the rocks in their original position. The second represents the first stage of decomposition by the erosion of a ravine and the formation of residual clay and manganese ore on the exposed edges of the manganese-bearing limestone. The third and fourth represent subsequent stages as already described.

The other figure represents a section through the Southern Hill, in Independence county. The disturbances in the chert are plotted from actual dips observed in the various manganese pits. It will be seen that a part of the manganese-bearing limestone remains in the northern end of the section, while in the southern end it has been entirely decomposed and its residual products are all that suggest its former presence.

[This subject as well as the manganese ores of other parts of the United States will be treated in full in the Report of the Geological Survey of Arkansas for 1888 to 1890.]

REMARKS ON THE CONSTRUCTION OF TOPOGRAPHIC MAPS FOR GEOLOGIC PURPOSES. By ARTHUR WINSLOW, Jefferson City, Mo.

[ABSTRACT.]

I DESIRE to present for the consideration of the Association this topographic model of a portion of the coal regions of Arkansas and I do this

for several objects. First, because of the interesting character of the topography represented and of its great geologic interest, and, secondly, I wish to give a brief description of the methods by which the maps for this model were constructed to show that their production is no very difficult matter if horizontal and vertical control is provided; and with a little perseverance and aptitude any man of technical training can prepare them. I further wish, then, to call attention to certain points in the construction of topographic maps which I think of special importance, particularly when made for geologic purposes.

The only instruments used in the production of these maps were the hand compass and the aneroid; the distances were paced. Horizontal control was obtained from the township plats of the land office and, since the prosecution of topographic work by the U. S. Geological Survey in the region, these plats have been adjusted to the triangulation. Vertical control was obtained from railway profiles and recently also from determinations of the United States Geological Survey. This matter of securing the necessary control will offer the greatest difficulty in some places; but wherever railroads are accessible, vertical control of at least provisional value is obtainable, and where the lines of precise leveling, either of the river or geodetic surveys can be reached greater accuracy is attainable. In the West the land office plats and the railway maps offer means for horizontal control which is of very fair relative value; while in the East, railway maps are similarly available and triangulation of government surveys is more abundant. With the extension of precise leveling and of triangulation by the national surveys opportunity for control is constantly increasing.

Each cadastral township, or area of thirty-six square miles, is worked separately. The roads and lines of prominence topographically are meandered out, the distance being paced and the line plotted in the note book and the adjacent topography sketched. The barometer readings are reduced to the absolute and the notes are then transferred in the field in pencil to a township sheet, termed a record sheet. This preliminary plotting in the field I consider of great importance to the faithfulness of the map. With careful practice this sheet should then be revised by comparison in the field by the geologist in charge of the work, and it is then transferred to the final sheet in the office and inked in, in appropriate colors.

The need of topographic maps and their great value have been long recognized, but this is becoming more and more appreciated. They are now in course of construction in connection with nearly all public geological surveys. But though topographic maps have been constructed for many years we still seem to be hardly out of the experimental stage, at least in this country, and especially in the matter of making such maps for special purposes. The methods of representation which have acquired extended use are confined to contours and hachures, or combinations of these, and probably the contour method is most generally adopted.

Though the mathematical principles of construction are well understood, the best manner of working according to these principles is not generally

recognized as yet. We have papers and text books explaining in detail the use of the stadia, the plane table and the aneroid for the construction of topographic maps. Students are well drilled into the conception of a contour and know how to plot such a map from the results of their surveys. Further, though the routine and mechanical process of such surveying is a subject of exact instruction, the cultivation of what may be called the topographic sense is generally entirely neglected. It is one thing to plot a contour line on a map so that it will connect the various points of the same altitude, but it is an entirely different thing to plot it so that it will be true to nature. Between the two cases lies all the difference between the mechanical and the artistic. In ordinary instruction topographic types are not clearly defined and thus the topographer often fails entirely to express on his map the proper topographic effect and presents an expressionless series of lines or dashes as a representation of features of relief which have shapes full of meaning.

One reason for this defect in contoured maps is because of excessive contour interval and this may be in two ways. First, the interval may be only a few feet and such as will permit representation of even the minor details of topography, yet the scale of the map may be so large that even with the steepest slopes the contour lines are kept well apart. Such maps are often necessary for engineering purposes, are often constructed with great exactness and in great detail, yet, for the reason indicated, they are often entirely expressionless. A diminution of the horizontal scale of the map would remedy this. The other case is that where the contour interval is a large one, too great for the character of the topography which is to be mapped. Here an equally expressionless sheet results; but here no mere change of scale will effect a remedy, for the special traits of the topography have no representation. Such maps show only general features; whether a country is mountainous, hilly or flat. (Illustrated by three diagrams) (Plateau Hills). Another common source of error in defective contoured maps is due to careless or inaccurate sketching; given the same data with two individuals, one will produce a good map, the other a poor one. Take for instance the case of a monoclinal ridge, of which the elevations of the summit and those of the adjoining valleys are known. By a careless spacing of the contours the monoclinal characteristics of the ridge will be lost entirely; whereas, with careful recognition of the differences of slope on the different sides of the ridge, they would be fully shown. Take similarly the case of a sinuous gorge, bounded by steep slopes produced by the sapping action of a stream. The characteristics of this slope so illustrative of the effect of such action may be entirely lost through careless spacing.

Now, these are geologic features as well as topographic features and they are but a few among a great host of features of importance geologically which are expressed in topographic forms. Hence, it seems to me, the more a man is able to appreciate this fact the more will his map be of geologic significance and value and, therefore, to attain the best results, topography should not precede geology, but should go along with it. But

In this connection, I do not wish to be misunderstood as implying that any warping or artificial magnifying of certain features is to be sanctioned in the construction of such maps for special purposes. All maps are necessarily approximations to an exact miniature of the surface they represent, the degree of approximation being proportional to the scale and to the amount of detail that can be and is shown upon the map. The detail necessary for all possible uses of a map can seldom if ever be shown on one sheet, hence arises the necessity of delineating with great exactness certain features and of allowing others to pass, according to the special ends for which the map is constructed. For geology maps are constructed for the special ends of geology; hence every care should be taken to see that the details of importance to the geology are not omitted, and, for this, the topographer must be able to appreciate the geologic significance of what he is mapping; in other words, he must be something of a geologist.

NOTES ON THE OCCURRENCE OF MUSICAL SAND ON THE PACIFIC COAST OF
THE UNITED STATES. By Dr. H. CARRINGTON BOLTON, New York,
N. Y.

[ABSTRACT.]

In a communication made jointly with Dr. Alexis A. Julien at the Philadelphia meeting of the Association in 1884, we showed that sonorous sand instead of being a rarity as commonly supposed, is widely distributed, and we referred to a list of seventy-four localities in the United States. With a single exception all of these were on the Atlantic coast, our efforts to secure by correspondence information as to the Pacific Coast having been at that time almost wholly unsuccessful.

During the earlier part of this summer I examined in person the sea-coast of California at several points and with the following results:—

Beginning at the southern extremity of the state I first visited: (1) Coronado Beach, San Diego. At this agreeable spot sonorous sand occurs in abundance, though of inferior quality; I first noticed it alongside of Prof. Henry A. Ward's Museum of Natural History near the Hotel del Coronado, and traced it at intervals for more than fifteen hundred feet west and the same distance east of this place; as the beach appears to be uniform in character it probably occurs throughout the entire length, about ten miles. The musical sand occupies areas of various sizes in a belt six to twenty feet wide, above the ordinary high-tide line; a less sonorous variety, emitting a shriller note, also occurs below the high-tide line on the surface only. Under the foot the sand is distinctly sonorous, and a tingling sensation is perceived in the toes when thrust into it forcibly, but these phenomena were less marked at the time of my visit than they are at Eigg, Manchester, Mass., Rockaway, N. Y., and other places. In a bag a loud sound is obtained. There are no dunes in the immediate

vicinity; the areas of loudest intensity evidently change their position from season to season, and from day to day; a certain area giving notable results one afternoon became moistened by an unusually high tide during the night and was thus deprived of its acoustic properties.

(2) Santa Barbara. Very weak, superficial sonorous sand was detected on the bathing beach near the long pier. The locality is unfavorable owing to narrowness of the sand belt and the abundance of algae.

(3) Redondo Beach, near Los Angeles. No sonorous sand was detected at the time of my visit, July 2.

(4) Monterey. Affirmative results at two places. On the bathing beach near the much frequented Hotel del Monte, is a tract of loose sand highly sonorous, equal apparently in power to that of Manchester, Mass. Also at Moss Beach, on the so-called seventeen mile drive. The sand here is unusually white and transparent, and is fairly sonorous on the surface.

(5) Pescadero. Sonorous sand has been reported by several persons to occur near the pebble beach at Pescadero, which I did not visit.

(6) San Francisco. Extensive sand dunes form a conspicuous feature in the ocean suburbs of San Francisco. Powerful winds from the broad Pacific drive the sand cityward and formerly threatened to submerge a shifting real estate—a region of "sand lots," world-notorious through the pseudo-oratory of a mischievous demagogue. Recently scientific arboriculture has reclaimed a large tract for the Golden Gate Park. Extensive dunes still remain, some of them measuring fifty to sixty feet on their steepest incline; on the lee side the sand lies at the angle of rest which here is 31° , the same as in Egypt, Bermuda, and the Hawaiian Islands. In the dry season the sand is quite mobile, but notwithstanding these favorable conditions it is utterly devoid of sonorous properties owing to its shaly and siltose constitution. The beach sand south of the Cliff House is also non-sonorous for the same reason.

(7) Laguna Beach. This beach lies on the ocean about five miles north of Golden Gate and was reached via Saucelito. The sand here too is shaly and wholly non-sonorous.

Reporting the occurrence of non-sonorous sand may be uninteresting but is not altogether superfluous, for negatives are of importance in establishing affirmatives.

(8) Mexico. Mr. W. W. Waddell now in Brazil, but a resident of Mexico for fifteen years, has furnished me with data of a sonorous sand hill in the peninsula of Lower California. A gentleman of accurate thought and a close observer of nature, he responded to my pertinacious questioning in so satisfactory a manner as to leave no doubt concerning the nature of the phenomenon and the character of the locality. In the year 185 just before the close of the dry season, Mr. Waddell was with a party of Mexicans on a schooner fitted out for the capture of turtles; they coasted along the Pacific shore of Lower California and made landings at many points. About sixty miles north of Cape San Lucas, the extreme southern end of the peninsula, the party landed and one of them climbed to the top of a dune to get a view of the neighborhood, in short to prospect for turtles,

and observed a sound issuing from the dry loose sand disturbed by his feet. Mr. Waddell standing near also heard the sound and having previously read of the Mountain of the Bell at once recognized the phenomenon. This dune is about seventy feet high (memory measure), and shaped like the half of a lens; its sides are covered in part with plants common to the region; it forms one of a range parallel to the coast and the sonorous slope faces the sea. The sand consists of ordinary quartz intermingled with a few broken shells. The sound produced by the sliding sand Mr. Waddell likened to that of bells, or rather to that made by rubbing the moistened finger on the edge of a glass bowl; not having a musical ear he was unable to recall the pitch.

The phenomenon was known to some of the Mexicans in the party, who narrated the following legend:—Many centuries ago there was a flourishing monastery at this place but owing to the wickedness of the monks it was overwhelmed by drifting sand. The monastery bells, however, were not involved in the fall of the monks, having been blessed with due ceremony by high ecclesiastics, hence the sound of these holy bells is still heard at matins and vespers.

The tradition resembles that of *Jebel Nagous*, Arabia, so far as the monastery bells are concerned, but is ingenious in accounting for both the underground condition of the priestly establishment and the survival of the music-yielding bells.

There are no villages in the vicinity of this sand hill, and the ranches in this desolate and arid peninsula are widely scattered; there are no attractions for commercial men or tourists, and the region is rarely visited by scientific travellers. The only similar sonorous dunes known to us are *Jebel Nagous* in Arabia, *Rig-i-Rawan*, Afghanistan, and one of similar name in Persia, *Nohili*, Kauai, and possibly one in Churchill county, Nevada. These we have described elsewhere.

THE "BARKING SANDS" OF THE HAWAIIAN ISLANDS. By Dr. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

ABOUT a year ago I read to the Association a condensed account of an examination of the Mountain of the Bell (*Jebel Nagous*) on the Gulf of Suez and of the acoustic phenomenon from which it is named. In continuation of my researches on sonorous sand,¹ which are conducted jointly with Dr. Alexis A. Julien of New York, I have now visited the so-called "Barking Sands" on the island of Kauai. These are mentioned in the works of several travellers (Bates, Frink, Bird, Nordhoff and others) and have a world-wide fame as a natural curiosity, but the printed accounts are rather meagre in details and show their authors to have been unacquainted with similar phenomena elsewhere.

¹See these Proceedings for 1883, 1884 and 1885.

On the south coast of Kauai, in the district of Mana, sand dunes attaining a height of over one hundred feet extend for a mile or more nearly parallel to the sea, and covering hundreds of acres with the water-worn and wind-blown fragments of shells and coral. The dunes are terminated on the west by bold cliffs (*Pali*) whose base is washed by the sea; at the east end the range terminates in a dune more symmetrical in shape than the majority, having on the land side the appearance of a broadened truncated cone. The sands on the top and on the landward slope of this dune (being about one hundred yards from the sea) possess remarkable acoustic properties, likened to the bark of a dog. The dune has a maximum height of one hundred and three feet, but the slope of sonorous sand is only sixty feet above the level field on which it is encroaching. At its steepest part, the angle being quite uniformly 81° , the sand has a notable mobility when perfectly dry, and on disturbing its equilibrium, it rolls in wavelets down the incline emitting at the same time a deep base note of a tremulous character. My companion thought the sound resembled the hum of a buzz saw in a planing mill. A vibration is sometimes perceived in the hands or feet of a person moving the sand. The magnitude of the sound is dependent upon the quantity of sand moved, and probably to a certain extent upon the temperature. The drier the sand the greater the amount possessing mobility, and the louder the sound. At the time of my visit the sand was dry to the depth of four or five inches; its temperature three inches beneath the surface was 87° Fah., that of air being 83° in the shade (430 P. M.).

When a large mass of sand was moved downward I heard the sound at a distance of one hundred and five feet from the base, a light wind blowing at right angles to the direction. On one occasion horses standing close to the base were disturbed by the rumbling sound. When the sand is clapped between the hands a slight hoot-like sound is heard; but a louder sound is produced by confining it in a bag, dividing the contents into two parts and bringing them together violently. This I had found to be the best way of testing seashore sand as to its sonorousness. The sand on the top of the dune is wind-furrowed and generally coarser than that of the slope of thirty-one, but this also yielded a sound of unmistakable character when so tested. A bag full of sand will preserve its power for some months, especially if not too frequently manipulated. A creeping vine with blue or purple blossom (*kolokolo*) thrives on these dunes and interrupts the sounding slope. I found the main slope one hundred and twenty feet long at its base but the places not covered by this vine gave sounds at intervals one hundred paces westward. At ninety-four paces further the sand was non-sororous.

The native Hawaiians call this place *Nohili*, a word of no specific meaning, and attribute the sound caused by the sand to the spirits of the dead, *uhane*, who grumble at being disturbed; sand dunes being commonly used for burial places especially in early times as bleached skeletons and well preserved skulls at several places abundantly show.

Sand of similar properties is reported to occur at *Haula* about three

miles east of Koloa, Kauai; this I did not visit, but prompted by information communicated by the Hon. Vladimar Knudsen of Waiawa, I crossed the channel to the little visited island of Niihau. On the western coast of this islet, at a place called *Kaluakahua*, sonorous sand occurs on the land side of a dune about 100 feet high and at several points for 600 to 800 feet along the coast. On the chief slope, 86 feet high, the sand has the same mobility, lies at the same angle and gives when disturbed the same note as the sand of Kauai, but less strong, the slope being so much lower. This locality has been known to the residents of the island for many years but has never been before announced in print. This range of dunes, driven before the high winds, is advancing southward and has already covered the road formerly skirting the coast.

The observations made at these places are of especial interest because they confirm views already advanced by Dr. Julien and myself with regard to the identity of the phenomena on sea-beaches and on hill sides in arid regions (*Jebel Nagous*, *Rtg-i-Rawan*, etc.). The sand of the Hawaiian Islands possesses the acoustic properties of both classes of places; it gives out the same note as that of Jebel Nagous when rolling down the slope, and it yields a peculiar hoot-like sound when struck together in a bag like the sands of Eligg, of Manchester, Mass., and other sea-beaches, a property that the sand of Jebel Nagous fails to possess. These Hawaiian sands also show how completely independent of material is the acoustic quality, for they are wholly carbonate of lime, whereas sonorous sands of all other localities known to us (now over one hundred in number) are silicious, being either pure silex or a mixture of the same with silicates, as feldspar.

The theory proposed by Dr. Julien and myself to explain the sonorousness has been already communicated, but may properly be briefly stated in this connection. We believe the sonorousness in sands of sea-beaches and of deserts to be connected with thin pellicles or films of air, or of gases thence derived, deposited and condensed upon the surface of the sand-grains during gradual evaporation after wetting by the seas, lakes or rains. By virtue of these films the sand grains become separated by elastic cushions of condensed gases, capable of considerable vibration, and whose thickness we have approximately determined. The extent of the vibrations, and the volume and pitch of the sounds thereby produced after any quick disturbance of the sand we also find to be largely dependent upon forms, structures and surfaces of the sand-grains and especially upon their purity or freedom from fine slit or dust (*Proceedings Am. Assoc. Adv. Sci.*, 38, 1889).

I should be lacking in courtesy to close this without expressing my great obligations to Mr. H. P. Faye, of Mana, and to Mr. Geo. S. Gay of Niihau, for both a generous hospitality and a sympathetic assistance in carrying out my investigations. [Photographs of the Nohill were exhibited, and samples of the sand.]

**FLORIDITE : A NEW VARIETY OF PHOSPHATE OF LIME. By PROF. E. T. COX,
New York, N. Y.**

WITHIN the last eighteen months there has been brought to the notice of the public the existence of immense beds of phosphate of lime, commonly called "Rock Phosphate" in contradistinction to the Carolina coprolites and gravel phosphate.

The name of "Rock Phosphate" cannot properly be applied to the entire mass, because much of it is of a soft plastic nature. From this fact, taken in connection with my opinion regarding its origin, I have applied to this variety of phosphorite the name of "Floridite" (Florida and *it is* a stone).

It is found in beds of large and small extent, formed of contiguous boulders of irregular shape that generally exhibit a laminated structure, with here and there narrow spaces between the laminae. Some of the small boulders have a botryoidal structure. Occasionally the broken masses show lachrymose markings as though produced by the flowing of a plastic substance. Other samples have a solid homogeneous structure with no sign of laminae. Then we occasionally find pieces that show very fine lines of lamination.

At some localities, associated with the rock phosphate, and at others constituting a distinct body, is a white plastic phosphate of lime. This plastic material contains a large percentage of water and when thoroughly dried crumbles into dust. It contains from 70 to 86% of bone phosphate.

These remarkable beds of phosphates I have traced from Madison county on the north to Lake Psala Apopka in the south part of Citrus county and have been told that they extend both north and south of these counties. They follow the trend of the Gulf of Mexico and are found over an area of about twenty acres in width.

According to the geologists who have made a study of the rocks of Florida, the phosphate rests upon rocks of the Eocene age.

The underlying rock is generally a carbonate of lime but in places it is a sandstone. Both the limestone and sandstone contain from 1% to 3% of phosphoric acid.

The depth of the phosphate deposit ranges from a few feet to thirty-seven feet and more. The latter being the depth of a shaft sunk at "Underwood," a mining camp sixteen miles due west of Ocala and in Marion county. This shaft is started on a surface crop and passes through solid phosphate to a depth of thirty-seven feet where water is reached. The bottom is still in high grade phosphate. The average of many analyses made of the phosphate from this shaft gives over 86% of bone phosphate.

The hard phosphate rock over the entire area that I have examined will average over 80% of bone phosphate.

The Dunnellen Phosphate Company, on the Withlecooche river, commenced mining last winter and are now shipping large quantities to Europe. Their output will soon be materially increased by the introduction of steam shovels and a system of overhead cable haulage. The phosphate rock is covered in most places with sand and clay to a depth varying from

a few inches to fifteen feet or more. At the time of my visit this covering was being removed by the use of spades and wheelbarrows. In order to get rid of some adhering sand and clay, the phosphate is roasted in heaps before being sent to market. In order to arrive at the average per cent of phosphoric acid, in a shipment, five barrow loads out of every hundred are placed in bags for analysis.

A hundred analyses made at the Shepard laboratory, under the direction of Dr. C. W. Shepard, of the Dunnellen phosphate rock, show that it averages above 80% of bone phosphate of lime, less than 8% of alumina and oxide of iron. Over fifty analyses made of the phosphate rock by Mr. Barrett on the property of the Florida Phosphate Company, at Underwood, in Marion county, give an average of 84% of bone phosphate of lime.

I do not wish to be understood as claiming that the floridite covers the one hundred and twenty miles north and south, and twenty miles east and west, mentioned above as the boundary of the mineral mostly determined by personal examination, as such a statement would be misleading. It is found over this area in detached beds, that sometimes are of small extent, while again it covers an uninterrupted area comprising a great many acres.

The question naturally arises, What is the origin of such a vast amount of phosphate material? It is a well known fact that phosphorus is an element and like the element of iron is almost universally distributed over the globe, and is found in all the living things thereon. Therefore, it is reasoned that it may, like iron, be accumulated in large beds by a natural law which governs the concentration of mineral masses. Again it is suggested that phosphoric acid, derived from mollusca, deposits from birds, fish and saurians, have filtered down and replaced the carbonic acid in the underlying limestone converting it into phosphate of lime.

Against the latter theory the phosphate of lime very rarely contains any trace of organic remains, while the limestone on which it rests is rich in the casts of mollusca that are referred to the Eocene age. Then again in proximity to the hard rock phosphate is a soft phosphate of lime that has the consistency of soft plastic clay. This soft phosphate often underlies the hard and is several feet in thickness.

My own opinion is that the "*Floridite*" is derived from the mineralization of an ancient guano. As the peninsula of Florida was elevated above the ocean the land bordering the sea on the west coast became the resting place of innumerable aquatic birds and other animals. The humid character of the climate caused the soluble alkalies to be removed leaving the less soluble phosphate of lime.

Guano has been found on some of the Pacific islands having a depth of two hundred feet which goes to show the vast amount of phosphate that is derived from this source and it requires no complicated phenomena of nature to attribute the hard rock and soft phosphates of Florida to the mineralization of an ancient guano. Large outcrops of floridite are seen, but it is more generally covered by a loose sand that might have been drifted by the winds before the present beautiful forests of yellow pitch pine covered the land.

The country containing the phosphate lies from sixty to one hundred and twenty-six feet above sea level, is generally level and free from an undergrowth of shrubs. A carriage can be driven anywhere through the pine forest without having to follow a beaten road.

On every hand we are met by the statement, from men who are not familiar with the chemistry of fertilizers, that the phosphates of Florida contain a large amount of alumina and oxide of iron which render it worthless for commercial purposes. While this is not the fact so far as the results quoted from Dr. Shepard show, as well as the numerous analyses that I have had made, yet there may be localities in Florida, that I have not investigated, where considerable alumina and oxide of iron are associated with the phosphate rock; but instead of phosphate of alumina proving detrimental, the reverse is actually the case, for phosphate of alumina is more readily soluble than phosphate of lime, consequently should prove a desirable constituent.

DIFFERENTIATION OF SUBTERRANEAN WATER SUPPLIES. By Dr. J. E. SIEBEL, Chicago, Ill.

[ABSTRACT.]

In this paper the author attempts to show that in localities favorable for the successful construction of artesian wells fixed relations exist between the composition of the different waters and the geological horizon from which they are derived. He demonstrates how, in spite of the defective and sometimes conflicting information obtainable from well borers, records, etc., these waters can be differentiated as to quality by measuring quantities and analyzing the waters at different depths from the same bore, by comparison of temperatures and by shutting off interfering supplies in cases in which the water does not all come from the same level as also by geological considerations.

In applying this to the underground water supply of Chicago and vicinity the author differentiates at least eight separate kinds of water, each possessing a different pronounced character as regards the predominating constituents and the stratum from which it flows. The author argues that not only our knowledge of water supplies and geological formations but also the material interest of those investing in artificial wells would be greatly enhanced if the keeping of correct records was always enforced by contract with well borers. The position of the author is sustained by a number of analyses and other facts and figures.

THE BENDIGO (BRAZIL) METEORITE. By Prof. ORVILLE A. DERBY, São Paulo, Brazil.

[ABSTRACT.]

A BRIEF statement of the history of the discovery of a meteorite weighing five tons, found in the interior of Bahia, Brazil, its transportation to the National Museum at Rio de Janeiro and some of its characteristics, accompanied by photographs of the meteorite.

OBSERVATIONS ON THE GENESIS OF CERTAIN MAGNETITES. By Prof. ORVILLE A. DERBY, São Paulo, Brazil.

[ABSTRACT.]

TWO localities, Ipanema, Jacupiranga, were described and evidence presented to prove that the magnetite occurs at those places in part as segregations, in part as an essential element in eruptive rocks belonging to the nephelinite and augite-syenite series.

NEPHELINE-BEARING ROCKS IN BRAZIL. By Prof. ORVILLE A. DERBY, São Paulo, Brazil.

[ABSTRACT.]

SEVERAL Brazilian localities were briefly described in which the granitic type of nepheline-syenite, or foyaite, occur associated with typical volcanic types such as phonolite, leucitite and fragmental eruptives in such a way to show that it is a volcanic rock in the most restricted sense of the term. Moreover the habit of many of the foyaite masses is that of a lava flow. Specimens and photographs of peculiar polyhedral inclusions or pseudo-crystals having the form but not the substance of leucite, of coarse grained foyaite in a fine grained phonolitic ground mass, were exhibited.

A NEW METHOD OF SEARCHING FOR RARE ELEMENTS IN ROCKS. By Prof. ORVILLE A. DERBY, São Paulo, Brazil.

[ABSTRACT.]

By the application of the *batea* or Brazilian miner's pan, a conical copper basin, a gravity separation of the elements of a decomposed or crushed rock is readily effected and the presence of microscopic grains of heavy minerals in proportions of one in a thousand or even less can be determined in a few minutes. By its use on Brazilian crystalline rocks the rare minerals zircon, monazite and xenotime have been proved to be very common and widespread, while others, such as perofskite, orthite, etc., have been detected in rocks where their presence would have escaped notice by any other method of examination. In illustration of the process a microscopic preparation containing a half dozen rare minerals including zircon and monazite, obtained by about five minutes' work from a drift boulder from Cayuga county, New York, was exhibited.

A NOTABLE DIKE IN THE MINNESOTA RIVER VALLEY. By Prof. C. W. HALL, Minneapolis, Minn.

[ABSTRACT.]

THE Minnesota river follows the course of the ancient river Warren described by General Warren and named by Warren Upham before this

Association in 1883, when a very extended description of the valley was given. The bottoms comprise the ground between the ridges of glacial material deposited in nearly parallel position along the north and south sides of the stream. In these bottoms lie nearly all the exposures of crystalline rocks which occur in southwestern Minnesota.

Among these crystalline rocks, mostly gneisses and schists, a number of dikes appear. These dikes are of varying width from almost paper thinness up to the magnitude of the one described. The usual position is the vertical, although occasionally, as at Montevideo, they conform with the lamination of the gneiss and thus obliquely reach the surface. In sections 28 and 24, Township 112: 34, and in Section 19, Township 112: 38, lies a series of knobs constituting the exposures of the largest dike known to the writer in southern Minnesota. Its width is from 165 to 175 feet. From the general erosion of the valley these knobs are all that remain of what is undoubtedly a great continuous dike whose general direction is E. N. E. and W. S. W. In texture this dike is medium with an occasional porphyritic feldspar crystal or a large individual of the pyroxenic constituent: its color is greenish black and under the hammer it rings sharply and breaks quite conchoidally. The rock is an altered diabase porphyrite in its mineral composition and chemically it does not probably contain over 48 or 50 per cent silica. The feldspar is plagioclastic lying for the most part in lath-like forms which extinguish at a high angle, from 35° to 45° ; the pyroxenic constituent is largely augite although some areas extinguish parallel thus indicating hypersthene. The pyroxenic contents have suffered much alteration, indeed not a single area but shows a portion changed into hornblende or biotite or both. Some other products of alteration are also present, particularly epidote and quartz. Magnetite and pyrite both occur quite plentifully.

This dike is of further interest in that it was probably formed at the time the great flows of diabasic material were poured out over thousands of square miles in northern Minnesota, Wisconsin and Michigan, and it marks the site and direction of one of the many fissures then made in the earth's crust over the northwestern states. The group of rocks constituting these flows, with some interbedded sedimentaries, is called Keweenawan by the geologists of the Northwest, who thus follow a suggestion made by Dr. T. Sterry Hunt in 1873.

SOME OF THE CONDITIONS CONTROLLING SUCCESSFUL ARTESIAN WELL-BORING
IN THE NORTHWESTERN STATES. By Prof. C. W. HALL, Minneapolis, Minn.

[ABSTRACT.]

It was the author's desire to determine for the United States Geological Survey the drift-covered boundaries of the Precambrian rocks which led to the investigations outlined. A map of the states North and South Dakota, Minnesota, Wisconsin and parts of Michigan and Iowa was exhibited

on which were represented the lines through which profiles had been drawn to show :

1. The depth of many wells in the states named together with their altitude above the sea.
2. The thickness and lithologic characters of the rocks penetrated in boring these wells.
3. The geologic age of the rock formations penetrated.

The water-producing basins of the several states were enumerated of which the following is a summary : the James river valley basin of the Dakotas; the Red river valley basin of North Dakota and Minnesota; the Mississippi valley basin of Minnesota, Iowa and Wisconsin; and several basins of Wisconsin already enumerated by Chamberlin and lying in the southern central and eastern portions of the state.

The conclusions which the author reached were as follows :

1. Over the northwestern states the surface elevations at which well-boring is successful, other conditions being favorable, vary greatly. Attempts to secure water from artesian and deep wells have been widely successful, provided the Precambrian crystalline rocks are at a sufficient depth below the surface to afford a reservoir space.

2. While a few deep wells yield a water unfit for domestic uses, the large majority of them afford an excellent quality of water.

3. At the present time no marked diminution of the supply from these wells is reported ; on the other hand the reports indicate the possibility of a much larger supply when it shall be sought for by further boring.

4. The surface and geologic conditions so far as these are now known point encouragingly towards a water supply from deep wells to the west and north of the Missouri river.

5. The rapid evaporation during the growing season in the states named and the estimated possible supply of water from deep wells forbids sanguine expectations of a sufficient supply for irrigating in the northwest; indeed it seems to be the part of wisdom to discourage as much as possible this use of artesian waters that a permanent and abundant supply for domestic uses may be assured.

CONCERNING SOME PORTIONS OF *CASTOROIDES OHIOENSIS* NOT HERETOFORE KNOWN. By Dr. JOSEPH MOORE, Richmond, Ind.

[ABSTRACT.]

PROF. J. A. ALLEN, to whom we are indebted for *Monographs of American Rodents*, as well as much of other valuable work, says of *Castoroides Ohioensis* :—"The species being known only from a few cranial and dental remains it is impossible to say much respecting its general form or probable habits. It may have been aquatic like the beaver but of this there is no evidence."

I am glad to be able to announce that within a few months past the

larger part of an entire skeleton was found in Randolph county, Ind., a few miles east of Winchester, the county seat. The general form of the body as indicated by this new find is quite similar throughout to that of the beaver, so that Foster, to whom we are indebted for the name as far back as 1888, did not misname the genus *Castoroides*.

The parts found recently would indicate an entire length for the animal of full five feet, nine inches.

From these remains the paleontologist will probably be better able to conclude correctly as to its relations and habits, than could be done by any one from the head alone.

It has heretofore been assigned not only a separate genus but a separate family, *Castoroldidae* (Allen), which classification will probably stand in the light of such further revelation as the late find will afford. It however seems evident that, as a summary of all the points of agreement and disagreement is taken, it will show a nearer structural relation to the modern beaver than what is indicated in the structure of the parts heretofore studied.

Possibly this genus may be found to fall properly into the family *Castoridae*.

The skeleton under consideration is somewhat larger than that of which the Clyde skull was a part, judging from the size and dentition of said skull.

As clearly indicated by the ribs of this Indiana specimen, the chest was large and expanded rapidly backwards from the first pair. The scapulae are more broadly triangular than in the beaver, the scapular spines are very prominent and thick at the outer edge, and the acromion and coracoid processes are a prominent feature.

The clavicles have the form and relative proportion as to size which mark a castoroid.

The legs, fore and hind, are in general quite similar to those of the beaver, except that the tibia and fibula instead of being separate are fused for near their lower half as in the musk rat. The fusion is even more thorough than in the latter and for a greater relative distance.

The greatest similarity to the beaver, in any of the members of the extremities, is in the humerus and femur, except it be in the structure of the hind feet. No fragment of a forefoot was found with which to compare.

We have no caudal vertebrae farther back than the seventeenth or eighteenth, though there must have been in all from twenty-two to twenty-five.

The tail was nearly if not quite as long and as stout proportionally as in the beaver. The transverse processes are similar in form to those of the beaver but are decidedly shorter in proportion and less blade-like. They are severally as broad fore and aft as the length of the centra to which they are attached. They curve forward making a deep notch between the forward spur and the anterior epiphysis of the centrum.

They are either perforate, backward of midway, at the base, or else bifurcate at the same point—the forward division curving forward and the posterior smaller division curving backward just as in the beaver. It is

somewhat difficult to believe that this giant extinct rodent should have a skeleton tail in so many respects similar to that of the last-named animal and not at the same time have been flattened like it, though evidently not to the same extent. I believe that specialists on examining such parts of the hind feet as we have will decide that they were once webbed. Further is it probable that an animal with such powerful incisors, the upper ones so massively buttressed behind, used them solely in procuring and in cutting its food? Does not this support from *behind* indicate that the animals bore their weight against the upper incisors in the act of gnawing down trees? It is evident not only from the teeth but from the remarkable size and strength of the lower jaws and from the extraordinary muscular attachments of the same that the extent of the creature's gnawing powers was quite commensurate with its size.

If they did gnaw down trees they probably built dams, swam about, lived in colonies. There is many a wilder fancy than that the subject of these suggestions helped to make the pond in the silt of which his skeleton was found buried.

Immediately below the silt is the drift gravel.

NOTE ON THE STONY METEORITE THAT RECENTLY FELL IN WASHINGTON CO., KANSAS. By Prof. E. H. S. BAILEY, State University, Lawrence, Kansas.

THE RECENT EXPLOSION OF NATURAL GAS IN SHELBY CO., IND. By H. E. PICKETT and E. W. CLAYPOLE, Akron, Ohio.

GEOLOGY OF INDIAN TERRITORY SOUTH OF CANADIAN RIVER. By Prof. R. T. HILL and JAS. S. STONE, Austin, Tex.

PROGRESS IN MORAINIC MAPPING. By Prof. T. C. CHAMBERLIN, Madison, Wis.

SUBSIDENCE AND DEPOSITION AS CAUSE AND EFFECT. By Prof. E. W. CLAYPOLE, Akron, Ohio.

GLACIAL ACTION CONSIDERED AS A CONTINUOUS PHENOMENON, HAVING SHIFTED FROM ONE LOCALITY TO ANOTHER. By Dr. P. H. VAN DER WEYDE, 286 Duffield St., Brooklyn, N. Y.

NOTES ON THE OCCURRENCE OF PEGMATITE IN CENTRAL MISSOURI. By ARTHUR WINSLOW, Jefferson City, Mo.

NIAGARA; A FEW LAST WORDS IN REPLY TO MR. G. K. GILBERT'S HISTORY OF THE NIAGARA RIVER. By GEORGE W. HOLLEY, Ithaca, N. Y.

TOPOGRAPHIC EVIDENCE OF A GREAT AND SUDDEN DIMINUTION OF THE WATER SUPPLY IN THE ANCIENT WABASH. By JOHN T. CAMPBELL, Rockville, Indiana.

A LOCAL DEPOSIT OF GLACIAL GRAVEL FOUND IN PARKE COUNTY, INDIANA. By JOHN T. CAMPBELL, Rockville, Ind.

THE GEOLOGY OF THE WICHITA MOUNTAINS, INDIAN TERRITORY. By Prof. THEO. B. COMSTOCK, Austin, Texas.

THE CRYSTALLINE ROCKS OF CENTRAL TEXAS. By Prof. THEO. B. COMSTOCK, Austin, Texas.

THE SILURIAN SYSTEM AND ITS GEANTICLINE IN CENTRAL TEXAS AND INDIAN TERRITORY. By Prof. THEO. B. COMSTOCK, Austin, Texas.

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ADDRESS
BY
CHARLES SEDGWICK MINOT,
VICE-PRESIDENT, SECTION F.

ON CERTAIN PHENOMENA OF GROWING OLD.

LADIES AND GENTLEMEN:¹—It is a difficult question to decide what is an appropriate subject for discourse on an occasion like this. It is necessary that it should be at once of a scientific character and of sufficient novelty and originality to fit an occasion of importance, and again, something which is readily understood by an audience of a somewhat miscellaneous range of interests. It would have been, of course, far easier for me to select some one of the special questions which I have been dealing with myself in my more recent study, but rather than do this I have selected a topic more difficult of treatment, to be sure, but at the same time more likely to be profitable and interesting to you. I make this choice because my subject will show that there is a new field, almost unexplored, in the domain of biology into which we are about to enter.

Most of you, I presume, are already familiar with the law of variations as we encounter it in the physical world. Let me offer an illustration, choosing the size of pebbles upon a beach.² The size of pebbles is apparently regulated by chance. If a great many of them are measured it is found that there is for a given beach a special size which occurs more frequently than any other. I will represent by a vertical line the number of pebbles of the most frequent size, and by neighboring equidistant lines the number of peb-

bles of other sizes. The diagram, Fig. 1, shows by the height of the lines that the number of pebbles is less the further we go from the most frequent size.

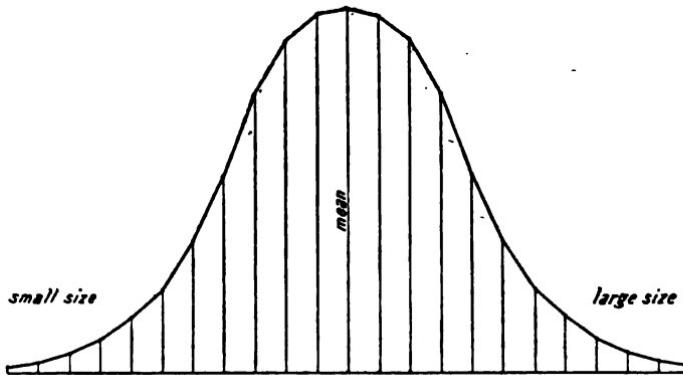


FIG. 1.

This progressive diminution appears equally for the sizes less as well as for those greater than the central size. In other words, the further the departure in size from the most frequent size, the fewer the number of pebbles we find of given dimensions; this is true in like manner of all physical variations. When we connect the tops of all these lines, which represent the number of pebbles, we get a curve which stretches away on each side of the maximum, and when it is drawn accurately and carefully it is found to be strictly symmetrical. This curve goes by the name of the binomial curve, and it is alike on its two sides.

All physical variations, which are produced by the common action of a large and varying number of causes existing in an infinite variety of degrees, present this same peculiarity in the distribution of the variations. When, however, we turn from the physical world to the living world we find that the law of variation is there very different. This can be shown in a great many ways. I have curves here which illustrate this. The first curve which is presented to you is one which is constructed in the same general manner as the one which I sketched for you in regard to the pebbles.

This first curve represents the age of the students who have entered Harvard College during a period of nearly twenty years.³

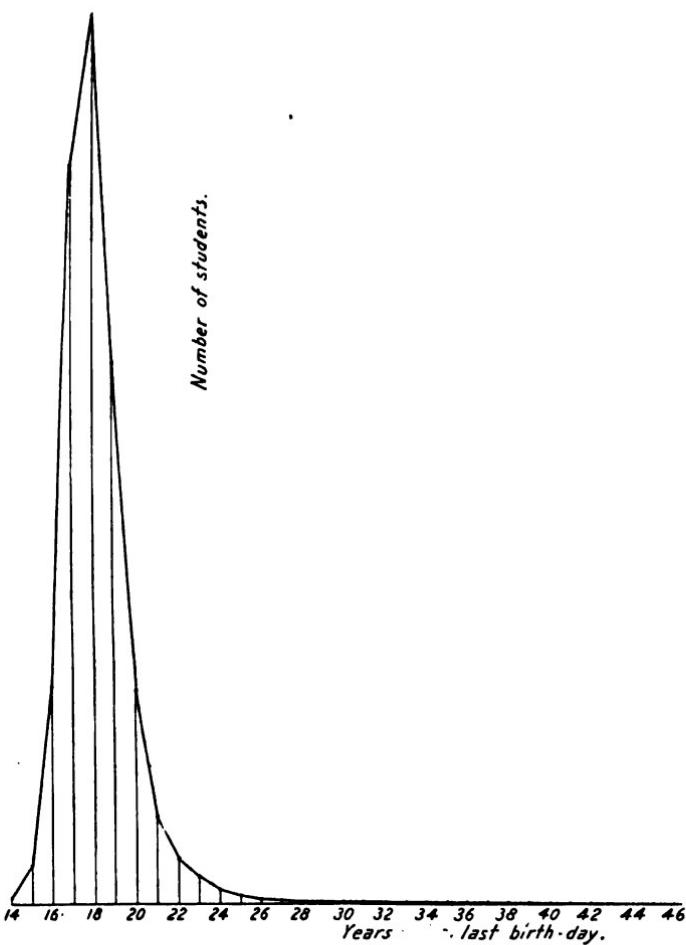


FIG. 2.

You will see that the number of students who enter at the first period of thirteen years is very small, but the number rises with great rapidity up to 2150 students who enter at the age of from eighteen to nineteen years. Then it falls off gradually, very gradually indeed, until we get to the oldest student, forty-five years of age; but there is no break anywhere in this curve. There are no sudden jumps, for the number of observations is so large that the curve becomes quite regular. We notice then that this curve

has the peculiarity of rising with great rapidity to its maximum, then falling off with rapidity at first but much more slowly than on the other side, and gradually extending out to a great distance. In other words, we see that the peculiarity of this curve is that the rise to the maximum is very steep on the side of youth, and that the fall from the maximum is much more gradual on the side of old age.

Here is a curve derived from another series of statistics. It represents the ages at which boys attain to a height—if I remember correctly, for this curve — of four feet, two inches. You will

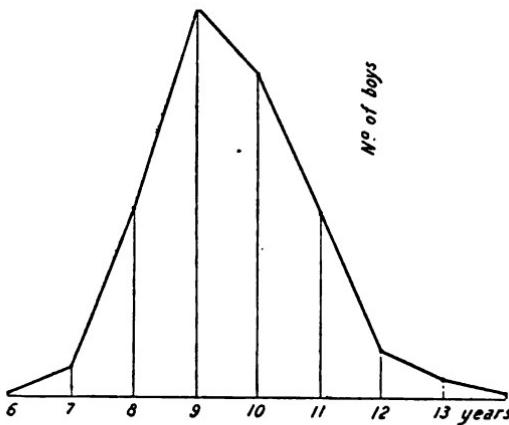


FIG. 3.

see here that the maximum comes at nine years and it rises gradually from six years and extends to fourteen. Here you see the same peculiarity, however, that the curve rises very rapidly on the young side to its maximum, and falls off more gradually. If we take the statistics which come from the determination of the age at which women become mature, the passage from girlhood to womanhood, we shall find that we get a curve, Fig. 4, which is very similar to this, except that the fall on the older side is even more gradual than is represented in the curve of Fig. 3. I have constructed a number of such curves, and find that they all offer the same contrast between their two sides.

Another set of statistics of which, however, I have not constructed curves, is that which gives the relation of the number of children born to the age of the mothers and demonstrates that the

maximum fertility is reached at an age between twenty and twenty-four years, and that the rise to that maximum on the young side is very rapid while on the old side the falling off is very gradual.

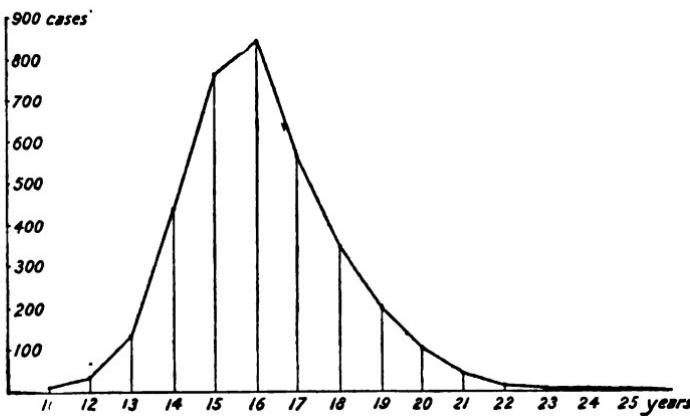


FIG. 4.

If we take the age at which recruits enter the army we obtain a curve of the same general character. If we take the age of marriage we find that also presents the same features and I might go on with a long list of statistics all leading precisely to the same result.

We learn that all curves of biological variation differ from those of physical variation in that, *first*, they are asymmetrical, and, *second*, show this peculiar relation to age. There can be, I think, no question that this alteration which makes the two sides of the curves so unlike is due to that series of changes which goes on in our organs, and which we speak of under the general term of senescence.

I must give warning against generalizing too promptly. In all the above illustrations of variation the maximum occurs at a comparatively early period of life. In other cases, as for instance when we study the relation of suicide to age, we find that the maximum frequency occurs at a much more advanced period and then the curve necessarily becomes steep upon the old side. In fact in the relation of variation to age we have a large field of statistical enquiry, for which there is already a large amount of material that might, if properly put into shape, yield valuable results. From this point of view one might study with profit the relation of various diseases to age, the relation of the birth of first child to the age of the parent, the age of second marriage, the age of entering

the United States senate, the age at which authors have published their first book, the age at which fame has been acquired,⁴ etc.,—all these and other similar data might be utilized by the biologist for the investigation of the laws of variation. At the present time sufficient work in this direction has not been done to enable us to draw any more general conclusion than that presented to you.

I do not propose this afternoon to enter into rivalry with that oldest and most famous of writers upon age, Cicero, nor shall I attempt to treat the subject with any of the eloquence which renders his essay so delightful to read; but though I cannot approach him in these literary respects I have the advantage of a large number of accumulated facts which enable me to present views as to age that I think Cicero certainly never had in mind.

It would be possible to treat of this subject far more satisfactorily from a statistical point of view, were it not that our statistics of vital phenomena are in an extremely unsatisfactory condition. To one who has worked a little in statistical matter, and gone far enough to gain some insight into the requirements of that method of research, it is astonishing to find how many elaborate series of statistics have been published which are so erroneous in the manner in which they are presented and the facts grouped that they are nearly valueless for scientific discussion. In order to have any good vital statistics, it is necessary that the exact age of the individual concerning whom the fact is recorded should be known, and that when the data are published they should be put in such form that the facts can be grouped by years; when the variation occurs with very great rapidity, as for instance, in the attainment of maturity in either male or female, it is necessary that the facts should be so published that they may be grouped in months, or even by weeks. These requirements have very rarely been fulfilled.

There could hardly be a better work for a State Board of Health to undertake than the compilation of good vital statistics. We have displayed in this country aptitude for that method of study, as is shown by the superiority of our census returns⁵ over those of other countries, and in the accuracy of our army statistics and those of various insurance companies. It seems to me, therefore, that we ought to look to America, where there is so much intelligence, where it is so easily possible to gather facts from the people themselves, for the collection of the best set of vital statistics that have ever yet become available for scientific purposes.

I, myself, have made a series of lengthy experiments intended

to give some further insight into the phenomena of senescence. For several years I had a large colony of Guinea pigs, which I selected because their period of growth is comparatively short—they attain maturity in something over a year—and it is possible to keep a large number of them, for they are of moderate size, and they have the further advantage that they are easily maintained in the condition of good health. The data of every individual was recorded, its weight at certain fixed ages, etc.; and of those measurements of its growth I have now between eight and nine thousand. In connection with these experiments on the growth, others of a general biological interest were going on, but the whole series of experiments, I regret to say, came to an untimely end. The animals were kept at the Harvard Medical School in one of the rooms of the basement, in large open pens, which gave them ample space for running about. The janitor tied up a bull terrier in the room, but during the night the dog broke loose, and the next morning ninety-six of my animals were lying on the floor shaken to death. Thus the work of nearly five years was in large part swept out of existence, for my experiments depended on their continuance for success. Had it not been for this mishap my results in regard to growth and other problems would have been far more satisfactory than they are now.

The data of the growth of the Guinea pig in weight⁶ are, I may venture to say, the most exhaustive series of statistics on the growth of any animal, not even excluding man, which we possess at the present time; they reveal a phenomenon which is illustrated by the chart before you. This chart shows you the percentage of the

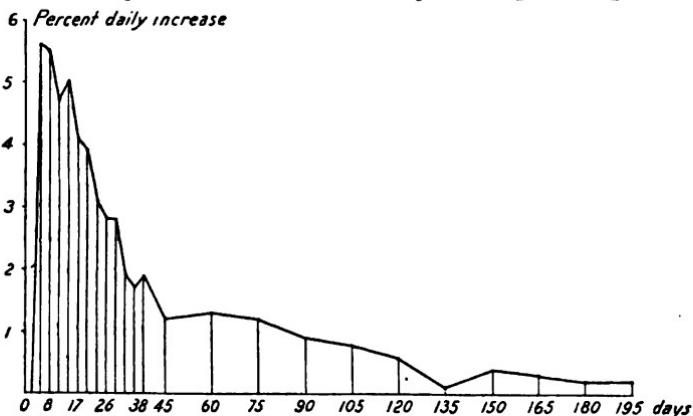


FIG. 5.

weight added to the original weight of the animal during one day's growth. On the left side of the chart the animal is supposed to be young and you notice that the percentage of weight which is added is from five to six. From that period onward to two-hundred and forty-one days, where the data of my experiments stop, there is a steady though slightly irregular fall in the percentage of weight. In other words, when measured by this means, the rate of growth of the Guinea pig declines almost from the moment of birth onward, and there is no such thing in the history of the Guinea pig as a distinction between the period of development and the period of decline. It is one steady decline when we measure the actual growth in this proper, exact manner.

The same law holds true of man, of chickens, of rabbits, of dogs, of ferrets, of all of which animals I possess sufficient statistics to speak with positiveness. In regard to man there are certain fluctuations,⁷ to be sure, which occur at about seven, eleven and fourteen years of age, in both sexes, but aside from these variations the progress of the decline is evident from the time of birth to the attainment of the adult size.

The particular curve shown to you, Fig. 5, represents the increase in percentages of males only. Here⁸ we have the similar curve of females, and you recognize in the female Guinea pig also, the same progressive loss in power of growth beginning at a very early period.

I have next another series of charts which illustrates by another means the same phenomenon occurring in the Guinea pig. I have calculated by a simple system of interpolation the length of time required to add ten per cent to the weight of the animal. Now if the animal grows very rapidly it takes but a short time and, as you see, the vertical lines representing those times are very short at the young period, but as the animal grows older the time it takes to add ten per cent to its weight constantly increases. Fig. 6 is the chart of the male Guinea pig, and the similar chart of the female is shown next.⁸ From these we learn that whereas the first ten per cent of addition is made in a time a little exceeding two days, the twenty-fifth addition of ten per cent is made in a period of nearly eighty-eight days.

I think the interpretation which we are to give to these facts is, that from the period of birth, which is as far back as observations go at the present time, there is a steady loss of vitality. The notion of development as opposed to decline may perhaps be illustrated

to your minds by comparing it to the construction of a wall by one man. The wall is built and grows larger, develops, but the man grows more and more tired, and as he grows more fatigued, and as

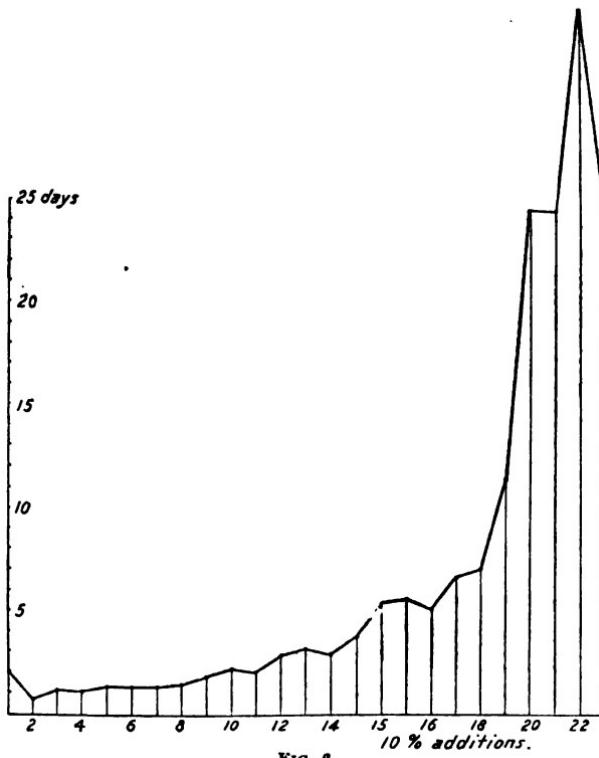


FIG. 6.

the wall becomes higher, the progress thereon becomes slower and slower, but the wall has developed all the while. So we see that the body develops all the time, but the power to continue the development of the body steadily diminishes.

This notion then that there is not from a scientific point of view any distinction to be made between development and decline, is the first generalization which I wish to present to you.

It will be interesting now to turn to the second part of our subject and inquire how far there are any anatomical peculiarities in the organism which can be correlated with this gradual loss of vitality. You will find in the anatomical text books a certain number of peculiarities of the various organs of the body noted as senile character-

istics, as belonging to old age ; the change in the shape of the lens of the eye, the induration or ossification of the ligaments and the tendons of the skeleton, and other changes of a like nature, are all carefully put down as characteristic of old age, but it is evident that they belong only to extreme old age, and do not represent or illustrate, so far as we can see at present, any general law or operation going on throughout the entire period of life.

It will be far more instructive for us to turn immediately to the comparison of the youngest with the adult tissues, and to see by close examination what distinctions we can find between the two. In the development of the embryo the germ layers are the first parts to appear. These germ layers are three in number : the outer, the middle and the inner. The outer one forms the external covering of the body ; the inner forms the lining of the digestive tract, and the third gives rise in great part to the muscles and connective tissue and skeletal elements of the adult, and the middle portion also gives rise to the blood and the blood vessels. These we may call the primitive parts. Now if we study these three layers as they exist in their primitive form, we observe that at first the cells of the outer layer have each a nucleus, and around that nucleus a small amount of protoplasm which in the chick at least is remarkable for assuming a triangular outline ; the nucleus and protoplasm constitute an epidermal cell. When we examine the adult skin of the chick we find that the cells which come there are cells more of this character⁹ in which the amount of the protoplasm is very greatly increased. If we examine, in a section of the embryonic intestine, the character of the inner layer cells which form its lining, we shall see that they form a distinct band around the interior of the intestine, and may be represented in this manner. The nuclei are crowded so very closely together, some lying higher, others lower, that the layer seems to consist principally of nuclei. In the adult intestine, we find that the same cells have this characteristic form, an oval nucleus often with a nucleolus ; the cell itself is elongated and contains a large amount of protoplasm. If we look at the embryonic connective tissue we see that it presents a similar difference from the adult, for we find a nucleus for each cell, and around that nucleus at first there is merely a tiny layer of protoplasm which sends off its delicate processes in various directions. If we examine the connective tissue corpuscle of the adult, we find that that is a large structure of this character, with a nucleus lying in its inte-

rior, and has very much more protoplasm than does the young cell. This embryonic connective tissue gives rise, however, not only to the connective tissue of the adult, but to various others, cartilage, bone, etc.; we find that the cartilage cell in one type occupies a large space with the nucleus surrounded by a considerable amount of protoplasm. The adult bone cell has somewhat of this shape, with an, usually, elongated nucleus, a considerable amount of granular protoplasm and processes running off through the canaliculi of the bone. If we examine the connective tissue cells in the tendon we see that they have this angular form, and are divided up more or less into plates which stick out in an irregular manner and produce this angular outline; we find in them the nucleus lying thus and the amount of protoplasm very much increased indeed. In the case of blood it is even more striking, for we see there that in the youngest blood cells of the bird we have a nucleus with a very distinct outline, and around that nucleus in the youngest blood cells there is merely a fine layer of protoplasm.¹⁰ If we follow the development we find in the latter stages of the embryo that the nucleus has become somewhat smaller and the amount of protoplasm has considerably increased; and in the adult bird we find that the blood corpuscle is oval in shape, large, has a relatively small nucleus and a great deal of protoplasm. We know that similar differentiations recur in the lymph glands, and in the lymph cells.

We have still a second group of tissues, those which arise later in the course of development, and which represent the more specialized organs and tissues of the body. I will consider briefly these in the following order: the nerve cells, the striated muscles, the liver cells, the pancreas cells, the cells of the thyroid and salivary glands, and of the spleen. Sections of the embryonic central nervous system show us that there is at first but one kind of cell. Some of these cells become hardened and form the skeletal portion of the central nervous system. Others undergo progressive development, and become nerve cells, or as they are often called the ganglion cells of the adult. The first trace of the development of these ganglion cells which we can distinguish in the embryo is the enlargement of the nucleus which appears somewhat irregularly granular in this manner. The amount of protoplasm at this time is so small that it is almost indistinguishable around the nucleus. Next the quantity of protoplasm increases. As development progresses the nucleus gradually becomes larger and larger, and in the case at

least of the large motor ganglion cells of the spinal cord becomes large, round, with a distinct nucleolus in the interior, and a slight network running from the nucleolus to the periphery of the nucleus. Around the nucleus comes a considerable amount of protoplasm, and at the time of birth the proportion of protoplasm to the nucleus, in the case of a ganglion cell, may be represented somewhat as I have sketched it here on the board. From the period of birth to that of adult life the quantity of protoplasm continues increasing and the outline of the cell body becomes finally at least as large in proportion to the nucleus as in this sketch. In the motor ganglion cells we can follow the progressive increase of protoplasm with the greatest distinctness.

In the striated muscle fibre we have a cell which has undergone a peculiar history. It is originally an epithelial cell, but it becomes separated from all its fellows, assumes an elongated form, and the nucleus, which it contained originally, divides so that the elongated cell has several nuclei. The length of the cell goes on increasing for a great while, but the size of the nuclei after they have been once developed does not alter much, and after they have attained their maximum number, which occurs quite early in their development, they do not multiply to any great extent, if at all. Whereas the young muscle fibre may be represented by this outline, the adult muscle fibre has increased to this diameter, and it would stretch so far, if drawn upon the same scale, that its limits would not appear upon this blackboard at all; it would be twenty or thirty times the length of the fibre when it is first differentiated. The enlargement is owing to the growth of the substance of the muscular fibre which has the contractile power, but is the means of locomotion, and is made up of protoplasm. Therefore we have in the striated muscle fibre a striking instance of the increase of protoplasm with age.

In the liver we find the same peculiarity; for the cells with a large nucleus, and but little protoplasm at first, develop into cells with a much larger body in the adult. It is not perhaps worth while to go on repeating these drawings for the pancreas, the thyroid and the salivaries. We can make one general figure for them. The young cell in all of these glands is somewhat of that proportion, and the adult cell is somewhat in the proportion of the sketch of the second figure; and it is the same way in the spleen. You recognize then from this review that in all the principal tissues of the

body we meet everywhere the same phenomenon of growth, namely, that with the increasing development of the organism and its advance in age we find an increase in the amount of protoplasm. We see that there is a certain antithesis, we might almost say a struggle for supremacy, between the nucleus and the protoplasm.

We have then to state as the general result of the studies which we have just made, that the most characteristic peculiarity of advancing age, of increasing development, is the growth of protoplasm; the possession of a large relative quantity of protoplasm is a sign of age.

The facts which we have rested our conclusion upon are drawn, as you have seen, entirely from the study of the vertebrates. It would be easy to show that of a great many of the invertebrates the same law holds; and it is probable that if we had sufficiently exact material to pursue this study throughout the whole animal kingdom down to the coelenterates, down to the jelly-fish and the polyps, we should find the same law reigning everywhere.

There are many special illustrations of the importance of this relation. I will mention three of these to you. *First*, when the production of a new being takes place, the ovum having been fertilized, the first change which occurs in it is an enormous increase in the amount of nuclear substance, an enormous multiplication of the nuclei in number; the effect of the impregnation of the ovum, of the seed in plants, seems to be an immediate production of nuclear substance; the production of nuclear substance, carried to extreme, converts the ovum after it is fertilized into a young organism and affords a fresh proof of the fact that the presence of a large amount of nuclear material is characteristic of youth. *Second*, there are certain animals which have the power of producing new parts or of increasing by division. Take, for instance, the class of the common jointed worms which multiply by budding. Here we observe in the middle of the long worm a zone of modified tissue appearing. That zone develops for the front piece of the worm a new tail, and for the hind piece of the worm a new head. The new tail and the new head serve to complete two worms where there was originally but one. The tissue, which does this, is tissue which, before it enters into its developmental accomplishments, assumes the young character, that is, it has a great deal of nuclear substance in proportion to the protoplasm; as it develops into the various tissues attached to the head and tail we see that it differentiates itself by gradual

metamorphoses and by acquiring more protoplasm in its cells. *Third*, take again these same worms which have to a great extent the power of reproducing their lost parts. One may cut off the head or tail of a jointed worm and it will grow again; and this reproduction is always accomplished by means of cells which assume the young character. These three instances teach us that this young character must be considered one of the essential conditions for maintaining a long continued growth.

I regret that my knowledge of botany is so imperfect that I feel in nowise authorized to discuss before you how far the generalization which I have drawn as based upon the study of the animal kingdom can be verified by what occurs among the plants; but I think it can be shown by further study by those who are competent, that the conclusion finds its verification in the vegetable world as well as in the animal. I will venture however to refer to Bütschli's recent investigations,¹¹ which lead to the conclusion that in bacteria the nucleus is present and very large, while the protoplasm is minimal in amount. This important discovery in conjunction with the extraordinary power of proliferation in bacteria confirms our generalization, that a small proportion of protoplasm is essential to rapid growth.

There are many directions in which investigation might be prosecuted to test this result farther, as for example in the regeneration of the lost arms of star-fishes and of the lost limbs of crabs, and other like instances.

One more fact I will point out before I leave this part of my subject and then I shall reach the general conclusion of my address. There are certain animals which have the power of continuing their growth for a very long period, such, for instance, as the star-fishes and many of the ordinary fishes of the sea; it is curious that we find that in these animals the cells have what I shall call the young character. They contain very little protoplasm.

On the other hand there are certain types which do not grow beyond a definite size and in these, as for instance especially among the insects, we find that the cells are characterized by having a great deal of protoplasm in proportion to the nucleus; so that it seems that everywhere we turn, evidence of a correlation between the growing power and the amount of protoplasm in proportion to the nucleus is encountered.

You perceive the point at which I wish to arrive. I wish to di-

rect your attention to the two sets of phenomena which I have discussed before you this afternoon in conjunction with another. I wish to ask you to consider that there is a progressive loss of vitality going on probably throughout the entire period of life, and that there is farther a relative progressive increase in the amount of protoplasm. The conclusion seems to me inevitable that there is a direct relation of cause and effect between these two phenomena, and I think you will regard me as justified in advancing at least as an hypothesis the belief that the development of protoplasm is the cause of the loss of power of growth. If I were to express the general result which I have to lay before you in the form of an apothegm, I should say that protoplasm was the physical basis of advancing decrepitude. You remember the old definition of protoplasm as the physical basis of life, and undoubtedly there is a certain truth in that; but it is, I think not a little curious to find that by combining the study of the statistician and the histologist we arrive at the somewhat unexpected conclusion—I think I may call it unexpected to you as it was to me—that protoplasm interferes with the power of growth.¹²

It is very unfortunate that this term, the physical basis of life, has been introduced. I suppose every one here has read some of those worthless essays upon protoplasm as the basis of life, wherein it is described as a simple jelly, whereby it is farther proved that protoplasm accounts for everything in a very simple way, that life is very simple and that the writer of the essay perfectly understands it, while it is a complete mystery to every thorough scientific man. I think it an unpardonable wrong for any one to assume that things are so simple when they are so complex, and the real reasoning ought to be that since protoplasm is able to accomplish all the manifold functions of life, and since these functions of life are extremely complex, it follows that protoplasm must have a complexity which is far beyond our present power of conceiving. We know in fact, from the recent investigations which have been made by the improved methods, and by the better lenses which are now at our disposal, that protoplasm has a vast range of complexity which was never dreamed of in the philosophy of those who talk about the simple jelly that explains the cause of life. I beg you all not to think that the half-humorous definition of protoplasm, as the physical basis of advancing decrepitude, expresses the scientific conclusion I wish to lay before you.

There is something else to be learned from the facts that we have had in our minds this afternoon. We have been dealing especially with a series of phenomena which are characteristic of the entire organism and are not confined to any of its organs or system of organs. The zoological part of biology has heretofore consisted almost exclusively of comparative anatomy and of physiology; in other words, in the morphology and physiology of the separate organs of the body. There has been extremely little scientific work done upon the peculiarities of the organism as a whole. It seems to me that in face of the living world we stand very much in the position of a scientific man who should study physics and chemistry in the laboratory and never have the slightest knowledge of geology, or the way in which the physical and chemical forces act in the world and throughout the universe. We should not study merely the organs of the body, whether in their anatomical or their functional relations. There are persons who never understand the arrangement which nature has established. We are always separating the things from their natural connection and taking up a special series of views instead of more general ones. There is in the direction of true *general* biology a vast opportunity which I hope will soon and generously be taken advantage of. There are many things which we can hope to understand only when study is prosecuted from that point of view. All of the important phenomena of reproduction, of heredity, of the evolution of species and of all the relations of actual organisms to the general economy of nature, of sex, of growth and variation, even of death itself, which is a problem I believe capable of scientific solution;—all these things are hidden away to a large extent from the morphologist and physiologist; they are open to the general biologist, and we recognize immediately when it is laid before us for careful consideration, that here is a great and unexplored field lying open to all those who have the patience and diligence to work in it. The results will be great. But something more than scientific enthusiasm and scientific capacity is needed for the prosecution of this kind of work. To carry it on properly large numbers of animals and plants must be kept under specific conditions for considerable periods of time—as you know, a costly undertaking; and if you will consider but a moment the small wealth of scientific men, I think you will feel that there are very few who out of their private means can enter upon such researches and undertake

these experiments. But beside those who pursue science as their professional work, there are many who have large means and generous impulses, and who have a real interest in science and a genuine desire to assist it. We see in the numerous institutions which are founded on every hand, in the endowments given to colleges, to libraries, to museums and to various public institutions, the proof that there is a most liberal and noble spirit on the part of men who take no active share in the work of science, leading them to do all that lies in their power to assist it. I hope among those who feel such impulses there may be some who will recognize that there is a new field open to them in which they may coöperate. There is an abundant crop of facts to be gathered. Zeal is there to harvest it and I hope that which is necessary to supplement zeal and ability, the wherewithal to carry out their purpose, may not be lacking.

I speak thus particularly of the advantage of the endowment of research in this way because I have had personal experience of the degree to which it is important. There has been intrusted to my care a fund which yields an income of something over a thousand dollars, which is appropriated exclusively to the endowment of research. Grants are made to meet the cost of investigations, which otherwise could not be carried out. Last year over twenty thousand dollars were applied for, and if we could have given fifteen thousand in response to deserving applications from men of acknowledged standing, the amount would have been wisely bestowed and have been worthily and properly used to the advantage of science. Such an experience has taught me that there is a greater store of scientific enthusiasm and capacity waiting for opportunities and means, than we have ever recognized. No other proof is wanted that the great need of science to-day is the endowment of research. I rejoice that this Association applauded so generously as it did the announcement made this morning that an addition, though not of very great amount, had been made to the small research fund of the Association. I think that nothing could more nobly commemorate a meeting of this Association than such a gift as came to us from Toronto. After this there will exist in the Association a permanent record of the hospitality and generosity of our Toronto hosts, and they will feel that they continue through us to contribute toward the direct promotion of science.

Wherever we turn we see scientific work of the highest quality delayed and even stopped for the lack of means. Everyone who can rescue these opportunities from being lost, even in part, will deserve well of mankind and deserve the acknowledgments of this Association.

NOTES.

¹ The address is given nearly as delivered. The changes have been confined to verbal alterations, except in the reference to the nucleus of bacteria, which is a subsequent addition, and in the closing paragraph, where the changes amount to rewriting the stenographic report.

² It would perhaps have been better to choose an illustration for which actual figures could be presented. I did, however, collect and weigh several years ago a considerable number of pebbles from a beach at Salem, Massachusetts, taking *all* pebbles I could find on the surface of a small area and obtained a symmetrical though somewhat jagged binomial curve. I regret now that I did not preserve the figures.

³ For the data concerning the students entering Harvard College I am indebted to the kindness of President C. W. Elliot, to whom I take this opportunity to express my thanks. The table on page 289 gives the ages in detail.

⁴ A curious study of this subject, the Age of Fame, has been published by Mr. Elliott in the International Review.

⁵ This was written before the disgraceful inaccuracy of the census of 1890 was known.

⁶ The detailed memoir upon the growth of Guinea pigs, is now in press and will appear in the Journal of Physiology.

⁷ These fluctuations are best shown in the tables of growth published by Dr. H. P. Bowditch in the Annual Report of the Massachusetts State Board of Health for 1873.

⁸ The curve referred to is omitted. It may be found in the memoir mentioned in Note 6.

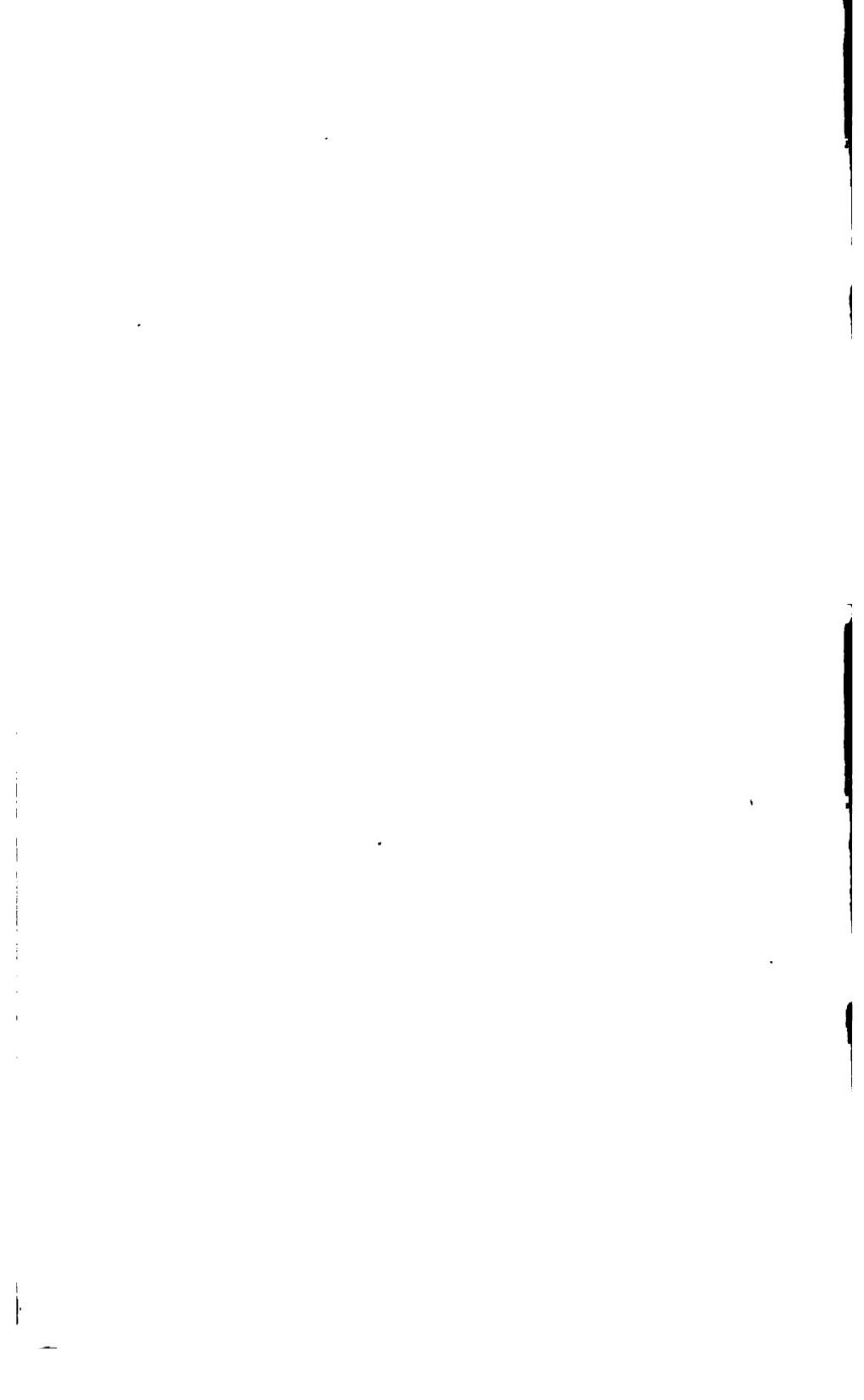
⁹ The appearances described were sketched upon the blackboard; as they are figured in the text books of embryology, histology and anatomy, it has been deemed unnecessary to add illustrations to the text.

¹⁰ The amount of protoplasm in the youngest blood cells is so small that some writers have overlooked it and erroneously held that the blood corpuscles arose as nuclei.

¹¹ O. Bütschli, Ueber den Bau der Bacterien, 1890.

¹² This law will perhaps give the clew to the intimate relation between the hypertrophy and degeneration and necrosis of cells. This relation is familiar to pathologists.

YEAR.	AGE										NO. ADMITTED.									
	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24										
1856	4	16	44	34	29	7	1	4	3	3	144									
1857	6	31	27	25	8	3	3	3	3	5	108									
1858	7	23	43	30	11	8	2	1	1	1	124									
1859	5	26	56	31	14	5	3	1	2	1	144									
1860	9	26	38	33	14	9	1	4	2	2	136									
1861	3	24	50	23	13	3	5	1	2	1	126									
1862	2	19	41	30	15	10	3	2	1	1	123									
1863	1	29	22	38	26	13	5	7	2	1	129									
1864	1	9	14	30	18	19	6	8	1	1	97									
1865	5	19	51	28	23	9	1	5	1	1	143									
1866	6	19	58	46	23	8	3	8	1	1	144									
1867	22	56	55	24	7	9	3	1	1	178										
1868	16	48	37	23	13	2	1	2	1	1	141									
1869	9	15	49	52	23	11	6	4	2	1	159									
1870	3	19	76	53	29	11	4	4	1	1	203									
1871	6	24	59	62	28	16	4	1	1	1	201									
1872	2	20	51	65	29	12	4	2	1	1	188									
1873	1	2	19	52	76	43	17	11	3	4	236									
1874	1	2	19	61	58	42	7	4	1	2	209									
1875	1	1	12	78	93	49	10	7	3	4	258									
1876	1	12	58	60	53	20	7	2	2	1	217									
1877	2	18	52	80	53	23	9	6	3	1	245									
1878	2	14	52	78	45	22	7	9	1	1	230									
1879	1	16	49	86	53	19	15	4	1	1	248									
1880	1	12	52	84	53	24	9	3	1	1	247									
1881	8	10	38	73	55	31	10	8	1	1	230									
1882	1	8	11	58	89	60	28	12	4	5	275									
1883	17	65	100	61	23	7	7	2	2	1	285									
1884	1	12	63	90	72	29	8	4	1	5	286									
1885	2	10	63	89	56	40	6	4	1	2	281									
1886	4	14	64	116	67	29	12	3	2	1	321									
1887	8	66	102	81	23	5	5	1	2	1	296									
1888	18	56	114	63	27	12	4	2	3	1	296									
1889	1	14	61	109	79	21	4	3	1	1	300									
Totals.	13	98	522	1775	2150	1290	514	206	103	67	34	22	11	5	19	4	1	12	1	6840



PAPERS READ.

THE RELATION OF THE MEXICAN FLORA TO THAT OF THE UNITED STATES.

By SERENO WATSON, Cambridge, Mass.

[ABSTRACT.]

The territory of the United States may be divided into three botanical sections—an Atlantic region, with rainfall sufficient for a perennial vegetation, extending from the coast to the states which border the Mississippi on the west, or more approximately to about the hundredth meridian; a Pacific region lying between the Pacific ocean and the Sierra Nevada and Cascade ranges, very narrow at its southern extremity, but near the British boundary extending eastward across northern Washington to the Rocky Mountains; and (3) an Interior region, embracing the arid eastern plains, the Rocky Mountain system (taken in its broadest sense) connecting more or less directly with the mountain system of Mexico and a broad, inner arid basin which is separated on the south by the high Colorado plateau from the valleys of Arizona and New Mexico. These two territories, together with much of southern California, may be considered as but the extension northward of the Mexican region. The Mexican flora, leaving out of consideration the purely tropical types, may be regarded as essentially one over the entire territory from the Gulf of Mexico to the Pacific.

By a comparison of the geographical distribution of the genera in various orders it was attempted to show that while there is a considerable element common to all of these regions, yet they are in a large degree distinct, and that the Mexican flora is more intimately connected with the Atlantic than with either the Interior or Pacific floras.

The orders that, like the Ranunculaceæ and Cruciferæ, are characteristic chiefly of temperate regions, are distributed alike through all three of the regions of the United States, with often certain genera that are peculiar to the several regions, and are represented southward in Mexico, or beyond, usually only in the mountains and by genera that are widely distributed elsewhere. Other orders are much more complicated in their distribution. But there remain many entire orders or tribes or groups of genera that are to a greater or less extent common only to the floras of the Mexican and Atlantic regions.

Among the Leguminosæ, for example, none of the Hedysareæ; excepting the northern genus *Hedysarum*, are found either in the Interior or Pacific regions, though *Desmodium* and *Stylosanthes*, which are largely represented in Mexico, are also common in the Atlantic. The large tribe Phasoleæ has no representative in the Interior or Pacific regions, though the species abound in Mexico, and six genera range from the Atlantic region far southward. The entire suborder Cæsalpineæ, so characteristic of the Mexican flora, is unknown in the Interior and has but a single genus (*Cercis*) on the Pacific, while it has its representatives throughout the Atlantic region, where also are the peculiar genera *Gymnocladus* and *Gleditschia*.

Of the Rubiaceæ, abundantly represented in Mexico and on the Atlantic, the tribe Galteeæ is the only one (aside from the genus *Cephaelanthus*) that is found either on the Pacific or in the Interior; and so of the Compositæ, the Vernonieæ are exclusively Atlantic and Mexican, and the Eupatorieæ are scarcely less so. Mexican genera of Asclepiadaceæ range only eastward to the Atlantic. The Melastomaceæ, abundant in Mexico, are represented in the United States only by one eastern genus (*Rhexia*) found as far north as New England. The tropical order Anonaceæ is found northward only in the Atlantic states. The Acanthaceæ, unknown in the Pacific and Interior regions, range from Mexico on the Atlantic side to Wisconsin and Vermont. Other as decided instances are found in the Bignoniaceæ, Verbenaceæ, Amaryllidaceæ, Araceæ, etc., and the number of more restricted groups or of single genera or even of individual species that might be cited is not small.

There are exceptions, as in the case of the Mexican genus *Cotyledon*, which is found elsewhere only on the Pacific, and the tropical genus *Quercus*, which is as abundantly represented on the Pacific as on the Atlantic side, but they are not conspicuous, nor do they appear to be very numerous. The subject is an interesting one and is worthy of a more thorough discussion than I have had the time to give to it, but an accurate and detailed comparison of the several floras would, I feel confident, only the more positively establish the principle here suggested.

GEOGRAPHICAL DISTRIBUTION OF NORTH AMERICAN UMBELLIFERÆ. By
Prof. JOHN M. COULTER, Crawfordsville, Ind.

THIS family is difficult to study from the standpoint of geographical distribution on account of the poorly defined generic lines. It is still a chaotic sort of group in which generic and specific lines seem to be of almost equal rank, and I have often thought that it contains but few good genera. Some have been cut off and stand out with great distinctness, but the bulk of the family is a nebulous mass of unresolved genera through which we run our lines very much at random. This makes the comparative study of

North American Umbelliferae very unsatisfactory without the immense labor of actual examination of all foreign genera. A statistical table, compiled from printed lists, is apt to miss the mark widely so far as the comparison of genera is concerned. Fortunately, the family is remarkably well defined, and so are the species, so that the mass-distribution can be easily ascertained, and so far as numbers of species indicate centers of geographical distribution these can be made out fairly well.

As at present understood, the family contains about 180 genera, a number which probably should be considerably reduced, and about 1400 species, a number which will probably be much increased. It is essentially a north-temperate family, with its greatest display in the Mediterranean region of Europe and on the great plateaus of Central Asia, while the Pacific region of the United States cuts no mean figure as third. Evidently having once flourished extensively in circumpolar regions when these were temperate, with a free intermingling of American and Asiatic forms permitted by land connection, they have been driven southwards by stress of climate and are still limited by temperate conditions. Very few survivors are to be found in arctic regions; for the same reason very few are to be found among our strictly alpine plants, and few have worked into the tropics except along the lines of temperate climate furnished by great mountain systems. I know of no great family with clearer temperature boundaries.

So far as North America is concerned, therefore, the Umbelliferae are massed in the United States, with a Canadian and Mexican penumbra. Within the United States there is a remarkable evenness of distribution, with a single notable exception. This general evenness of distribution may be shown by the following figures. There are on record 224 species of North America Umbelliferae north of the Mexican boundary, just 16 per cent. of all the Umbellifers known. No attention, of course, is paid to introduced species. In the region of Gray's Manual there are about thirty-six species: in that of Chapman's Manual forty species; in that of the Rocky Mountain Manual forty-three species; in the Great Basin thirty-seven species; along our Mexican border about forty species. In short, in those regions which have been considered distinct enough to mark out manual limits, there is a wonderful uniformity of about forty Umbellifers in each. Of course this does not mean forty species peculiar to each of these regions, but all those found growing within them. This comparison is somewhat unfair for two reasons, viz.: the difference in area of the regions compared, and the artificial nature of some of the boundaries, notably that between the manual of the northern and southern Atlantic States. The long southern extension of the Alleghanies, and the northern extension of the low-lying coast lands have brought such an interlocking of northern and southern forms that their separation cannot be expressed by a parallel of latitude. However, in the comparisons made, I have excluded from southern forms those that are only such on account of the Alleghanies, and from northern forms those that are only such on account of the lowlands of the coast. Therefore, I think the point of great uniformity of distribution fairly well made.

Knowing that the mass of our Umbellifers has spread southwards from regions that are now arctic in climate, and that they are largely tainted with Asiatic blood, twenty-five of our fifty-three acknowledged genera being in common with Asia, I must confess to some surprise at first that the great Rocky mountain system was not more used as a highway for this southern migration. But it seems to have been no more favored than any region to the east of it, unless the great plains be excepted, only having its share of a continent-wide distribution; each region, including the Great Basin, receiving about eighteen per cent of our species. For some reason, therefore, the different botanical regions east of the Sierra Nevadas are about equally well adapted to Umbellifers and none of them specially favorable to them.

Turning now to the great Sierra Nevada region, under which we would include the three Pacific states and their mountain ranges, we find one hundred and twenty species, about fifty-four per cent of our Umbellifers, considerably more than half. This at once points out a region especially adapted to the needs of this family, and along which it seems to have chiefly spread in its southward movements. It seems to have long been a region very favorable either for the preservation of old types or the evolution of new ones, and whether our great display of Sierra Nevada species represent ancient or recent ones I have no means of judging, but I incline to the latter view. Suffice it to say, it represents for us at the present day the region in which North American Umbelliferæ are most heavily massed. I am not prepared to suggest what peculiar climatic or soil conditions find such ready response in the Umbellifer plant-body, but it is a subject worth cultivating.

If the Sierra Nevada region contains the greatest display of Umbellifers characteristic of North America, and I should be asked to point out the most characteristic forms of this region, I should at once refer to the great display of acaulescent dry ground Peucedanums and their allies. The genus *Peucedanum* is undoubtedly the great North American feature of Umbelliferæ. Like *Astragalus* among Leguminosæ, western collectors are constantly supplying us with new *Peucedanums*, until it would seem that in certain groups almost every station has its own *Peucedanum*. This statement does not carry its full force when by the book one sees that the genus is not peculiar to America, but that half its species are foreign. But although the genus *Peucedanum* is not peculiar to America, the great group of American *Peucedanums* is peculiar. American *Peucedanums* form a group by themselves by a community of characters that I do not care to enumerate here. Bentham and Hooker could include *Pastinaca* and our *Tiedemannias* among foreign *Peucedanums*, but not among our own. For our purpose, then, *Peucedanum* is a peculiarly American group, probably genetically related to the foreign genus of that name, but separated from it by so long a time and such different conditions as to have worked out a distinct facies of its own.

Forty-eight species of *Peucedanum*, good, bad and indifferent, are now known to occur in North America, north of Mexico, representing more

than twenty-one per cent. of our umbelliferous flora, and not one of them has crossed the Mississippi river. Only three of them reach the prairies and belong distinctly to the Great Plains; only eight are found in the Rocky Mountain region; ten are found in the Great Basin; while the Sierra Nevada region as defined contains forty species out of the forty-eight, or over eighty-three per cent. of them. This genus, therefore, plays an important part in the predominance of the Pacific States in Umbelliferae. To narrow the matter still farther about thirty of the forty species are found in the mountains of Washington and Oregon, which seem to be the very hotbeds of *Peucedanum*. Either the conditions in this region are exceedingly favorable for breaking up this vigorous type into spray, or we have yet to learn the possible range of variation within the limits of a species.

Another vigorous type of the Pacific States region, and one which knits it closely to northern Asiatic forms, is *Angelica*, more than half of whose species belong to North America, the remainder being practically Asiatic. Of our sixteen species, one-half are in the Pacific States, the remainder being distributed by twos and threes in other regions.

After *Peucedanum*, the peculiar cut of Pacific Umbellifers is furnished by the genus *Sanicula*, nine of whose ten American species are in the Pacific States and nowhere else. In fact, although the genus *Sanicula* is world-wide in the distribution of two or three species, its characteristic abiding place is in the Pacific States. The same is true of the genus *Selinum*, which enjoys the distinction of being our most arctic-loving genus, and has extended no further eastward than the Rocky Mountains. Four of our seven species are in the Sierras, and three extend to Alaska, closely connected with species of arctic Asia.

The genus *Leptotænia* is characteristically Pacific and peculiar to North America, five of its seven known species belonging to the Pacific Coast States, the other two to the Great Basin and the Rocky Mountains. This distribution of *Leptotænia* is to be expected when its close relationship to *Peucedanum* is remembered, for these two genera have not been thoroughly disentangled yet, and in geographical distribution *Leptotænia* should count as *Peucedanum* stock.

Eulophus and *Carum* are both Pacific genera, and are for our purpose to be counted as one, for they are very closely related, each being represented by four species in their peculiar region, and only a single species of *Eulophus* being found anywhere else.

Osmorhiza is another vigorous Pacific type, while *Velæa* gives to the Pacific states their strongest flavor of Mexican types, being closely related to the genus *Arracacia*, so characteristic of the cooler regions of Mexico and the South American Andes.

To summarize at this point: the great proportion of our Umbellifers has come from the north; they have found by far the most favorable conditions in the mountainous regions of our three Pacific States; they there present not only numerous species, but also a few groups of genera so closely related as to argue their recent origin; very few types have survived at the north and none of them show generic divergence; a few types have ex-

tended further southward, into and through Mexico, and even into the Andes, and although they retain a close resemblance to corresponding northern types they have, in many cases, become so distinct as to be described as distinct genera; the characteristic facies of the Pacific region is given by its species of *Peucedanum*, *Angelica*, *Sanicula*, *Selnum*, *Leptotænia*, *Eulophus*, *Carum*, *Osmorhiza* and *Velesa*, which with their very apparent and poorly separated offshoots represent seventy-five per cent. of the umbelliferous flora of this region and more than forty per cent. of all North America Umbelliferae.

I wish to speak briefly of certain dominant types in other regions:

The Great Basin naturally contains those contiguous species of the Sierra Nevadas and Rocky Mountains that can endure its peculiar soil and climate, but in addition to these, it contains certain types peculiar to itself, types which are very evidently the result of the Great Basin impress, though their ancestry cannot be so definitely stated. *Cymopterus* and its ally *Coloptera* represent sixteen arid ground species, ten of which are Great Basin forms, the others extending into similar conditions in the Sierras and Rocky Mountains, across which latter range three species have passed and find most congenial homes in the arid stretches of the Great Plains. Beyond all others, *Cymopterus* stands as a Great Basin type, through *Coloptera* connected with the *Leptotænias* and *Peucedanums* of the Sierra region, to which vigorous types I think we must look for the origin of some of its species, while others bear a no less marked Rocky Mountain impress, connected by certain genera formerly included under *Cymopterus*, such as *Oreoxis* and *Pseudocymopterus*, with that vigorous Rocky Mountain type, *Ligusticum*. It is as though the Sierra *Peucedanums* and the Rocky Mountain *Ligisticums* in attempting to occupy the Great Basin had been modified into a Great Basin type that we call *Cymopterus*, and that we have the intermediate phases in such types as *Coloptera* and *Leptotænia* on the one hand and *Pseudocymopterus* and *Oreoxis* on the other. This may be purely figurative, but it expresses relationships.

The Rocky Mountain region is characterized by the presence of two closely related genera, which for our purpose may be considered as of one stock, viz.: *Ligusticum* and *Pseudocymopterus*, and three monotypic and exclusively Rocky Mountain genera, viz.: *Oreoxis*, *Harbouria* and *Aletes*. These all represent fifteen species, eleven of which belong to the Rocky Mountains. Why the Rocky Mountain region, and chiefly that of Colorado, should contain four genera found nowhere else, and one of these represented by three species, while the far richer Pacific region contains but two such, and these monotypic, is a question I cannot answer, unless it means longer time, or more isolation, or both, or mistaken judgment concerning genera.

The Great Plains represent the most poverty-stricken region in the distribution of Umbellifers, so far as any records show. Only fifteen or twenty species are recorded from this region, and these, for the most part, of such wide range as to belong to other regions as well. But in spite of this, a characteristic genus from the Great Plains of British Amer-

ica, *Musenium*, extends into the northern stretches of our "Plains" region, while to the far south, in the Texan plains, a monotypic genus with the very suggestive name *Museniopsis* makes its appearance and immediately connects with certain Mexican types. *Musenium* has also worked its way well down the foot-hills of the Rocky Mountains, and the striking resemblance of this strong type of the Plains to the peculiar monotypic *Aletes*, which once bore its name, as well as to *Harbouria* in certain of its forms, suggests a possible origin for these monotypic genera of the Colorado Rocky Mountains.

In passing I desire to call attention to a very peculiar minor region, which may be as distinctly marked zoologically as botanically so far as my information goes, viz.: the prairie region that extends from southern Missouri through parts of Arkansas and Indian Territory, and includes northeastern Texas. This comparatively small region is not rich in its number of Umbellifers, containing probably hardly a score of species, but it has four genera peculiar to it, representing eight species. This really calls for an explanation, and I can only suggest one. There are indications among some of its Umbellifers that this area is a Mexican loop, but if so, a former promontory has become well nigh an island botanically. The four genera referred to are *Trepocarpus*, *Eurytænia*, *Cynoscladium*, and *Ammoselinium*. Besides this, the only native species of *Bifora* on the whole American hemisphere is confined to this region.

Curiously enough, the North Atlantic States region, that covered by Gray's Manual, and by far the best known region, is the least interesting of all in its display of Umbellifers. It has no genus peculiar to itself, excepting *Erigenia*; no genus specially displayed, unless it be *Hydrocotyle*, six of whose seven species are to be found within its limits, but nearly all of them are found elsewhere as well. The *Thaspium* and *Zizia* forms are prominent, but hardly more so than in the south. If the North Atlantic States be taken alone, *Erigenia* alone characterizes them; if North and South Atlantic States be taken together, *Thaspium* and *Zizia* would distinguish the area from any western one.

But the South Atlantic and Gulf region is by no means so featureless, for there is there displayed in great abundance our second largest genus, *Eryngium*. *Eryngium* is as fond of the southeast as *Peucedanum* is of the northwest, and it as distinctly characterizes its region. In fact, were it not for *Eryngium*, our South Atlantic and Gulf region would fall far below the average of forty species. If the Sierra Nevada region shows a great movement of Umbellifers from the north, the Gulf region indicates a strong advance from the south in the display of *Eryngiums*, for this genus is principally developed in the warmer regions of the globe. There is no northern resemblance that would suggest a possible northern origin, for not only its present display, but all its affinities are southern. Of our twenty-three species, only one extends into the North Atlantic States, thirteen belong to the southern states, five are found along the Mexican border, and five have worked to a greater or less distance up the Pacific coast, while a troop of Mexican and South American forms in the background

plainly indicate the direction of advance. The only other characteristically southern genus is *Tiedemannia*.

Such are the main facts with reference to the distribution of North American Umbelliferae, facts which may or may not be consistent with various schemes of geographical distribution, schemes which I have purposely avoided for fear of being tempted to twist my facts, and preferring that their application should be made by the authors of bio-geographical maps.

In conclusion, the following statistics of the family may be of general interest:

Of our fifty-three genera, twenty-three are strictly North American.

Of our two hundred and twenty-four species, two hundred and eleven are endemic.

Six of our genera are restricted to North America and Asia.

No genus is restricted to North America and Europe.

Four genera are common to the whole northern hemisphere not extending southward.

Sixteen genera are world-wide in their distribution.

Twenty-five of our genera are also found in Asia.

Of our thirteen species found elsewhere, ten of them are Asiatic, and the remaining three are from South America.

Twenty-two genera and one hundred and sixty species are restricted to west of the Mississippi.

Seven genera and forty species are restricted to east of the Mississippi.

Only ten species can be considered really alpine.

Thirteen of our genera are monotypic, while eleven additional genera are represented within our borders by but a single species showing that nearly one-half of our genera are represented by single species.

THE DISTRIBUTION OF HEPATICÆ OF NORTH AMERICA. By LUCIEN M.
UNDERWOOD, Syracuse, N. Y.

THE committee who arranged this series of papers on the distribution of North American plants could not have been aware of the fragmentary knowledge we possess of the distribution of the Hepaticæ in North America, otherwise this paper of the series would certainly have been omitted. There is possibly no other major division of plants of which we know so little of the range of species in latitude, in longitude, or in altitude. A few small areas of our country have been more or less carefully studied. The White Mountain region, the southern portions of New England, the region of Central New York, of Northern New Jersey, of Central Ohio, a few counties of Illinois, the District of Columbia, parts of the Appalachian region, small areas of Florida and the environs of San Francisco have been examined but not exhausted by American collectors. Over the greater portion of our region the higher vegetation has been taken and the hepaticæ left. Of the hepatic flora of Louisiana, Texas and the great southwest almost nothing is known; over the greater portion of Florida and the

Gulf region the collector of hepaticas has never wandered; the Rocky Mountains, the Sierras, and the rich bryophytic regions of Oregon and Washington have never yet had their hepatic treasures revealed, and the same is true of many other portions of our country. In the provinces north of the United States much larger collections have been made, mainly through the untiring energy of Prof. John Macoun, and from the border-land of these possessions, Mr. Leiberg has already sent enough material to disclose the presence of an extensive hepatic flora from the region of Pend d'Oreille. The straggling and scanty collections gathered here and there over the country must form the basis for what can be only a paper of preliminary notes on the distribution of the American Hepaticæ, for a large collection of American species has not yet been brought together. The Austin collection is probably the largest in existence, but no American botanist has seen it since its purchase by Messrs. Carrington and Pearson of Manchester, England. My own, probably the next in size, has been largely accumulated since 1885 and is doubtless the largest on this continent, but is still lacking in a number of the described species and can furnish only fragmentary data on matters of distribution. The only public collection of considerable size in the country is that preserved at the Gray Herbarium, but aside from the Sullivant collection, it contains in American material only the published exsiccatæ of Austin and Wright.¹ It is interesting to learn that the Torrey Herbarium has recently received from Mr. Pearson some of the types of Austin's species which hitherto had not been represented in any collection in this country.

In thus advertising the poverty of material on hand we hope to impress on botanists the desirability of making local collections which, if centralized, will serve in future for work in this direction.

How far this local collection is a necessity is thoroughly illustrated by the fact that every corner hitherto explored brings to light new and unexpected forms. A large number of species accredited to America are known only from the specimens which Austin collected in the vicinity of Closter, N. J., and careful searching in other regions will furnish others of equal interest. Here in Central New York we have recently picked a *Lejeunea* (*L. Austinii*) which hitherto had not been found north of the Carolinas. *Jungermannia exsecta*, more commonly found in mountain regions, grows with other northern plants like *Ribes lacustre* about the cold springs of our "Scolopendrium Lake,"² while *Fimbriaria tenella* fruits in profusion on our warmer lowlands, coming among us like *Listera australis* from a lower latitude and a warmer cline.

The task then assigned us can be performed only by marking out a few rude outlines, taking ground tentatively rather than dogmatically and suggesting probabilities rather than stating facts.

The group of Hepaticæ as described from the entire world includes

¹It should not be forgotten that the Gray Herbarium contains the extensive Taylor collection, containing valuable material mainly European and exotic. It contains, however, some of the types of Taylor's American species and has, therefore, some local value. In general value it ranks with the large collections of the world.

²Jameaville, N. Y., where a number of northern plants may be found in the cold ravine about Green Pond.

above twenty-five hundred species.¹ In order to give some general idea of the distribution of the group as a whole, we have selected two of the larger genera *Frullania* and *Plagiochila* whose distribution is peculiarly widespread; they are further selected as representative types of the two great tribes of the Jungermanniaceæ,² itself the largest and most highly differentiated of the orders of the Hepaticæ.

From the showing on the following table, which will not unfairly represent the entire hepatic flora, we may derive certain general conclusions:—

1. As among all cryptogams the tropics are most prolific in species, and the profusion is said by travellers to be equally marked.

2. The hepatic flora of the southern hemisphere is proportionally more extensive than that of the northern.

3. The insular flora, especially in the southern hemisphere, is a marked feature. The percentage of endemic species is also marked. Of the forty-seven Javan species of *Plagiochila* only fourteen are found elsewhere. Of the twenty-two New Zealand species all but four are endemic.

4. In continental areas those possessing abundant forest growth, combined with excessive humidity and high temperature, are most likely to be prolific in Hepaticæ. The valley of the Amazon and the eastern slope of the Andes fully meet these conditions, as the results of the long-continued travels of Dr. Spruce have abundantly demonstrated.³

Countries bordering on warm seas where the prevailing winds are shoreward, and the rainfall is considerable, are also favorable regions for the development of this group. Certain portions of Mexico and the Himalaya region seem to possess these conditions.

The close connection of the bryologic flora of both continents of the northern hemisphere has been often remarked. It will, therefore, not be surprising to learn that among the 265 species of hepatics known from America, north of Mexico, 127 are also found in Europe, and the proportion of species common to the two continents regularly increases as we pass northward into the boreal regions of North America.

From Mexico 212 species have been reported⁴ of which only a small portion are of species growing farther north, a condition likely to be changed when the hepatic flora of the southwest shall be made known.

Europe, with 825 species, shows the effect of the early work of Hooker, Nees, Gottsche, Lindenberg and Taylor, supplemented by the later labors of Spruce, Pearson, Massalongo, Stephani, Limpricht, Jack, Lindberg and numerous other workers, and even in that well-developed region new forms are constantly coming to light.

¹In the *Synopsis Hepaticarum* (1844-7) are 1641 species. As no general summary has since been published an estimate is difficult. Additions have been numerous and some idea will be furnished by noting the increase of certain genera. *Frullania*, according to our count, has increased from 155 to 215 species. *Radula* from 40 to 130 (cf. Stephani, *Hedwigia*, XXIII, 156, 1884) and *Bazzania* from 63 to 167 (cf. Stephani, *Hedwigia*, XXV, 238, 1886). These data would seem to place the above estimate too low rather than too high.

²Cf. Spruce, *Hepaticæ of the Amazon* (1885).

³Over 550 species are described in his *Hepaticæ of the Amazon and of the Andes of Peru and Ecuador*, of which a large proportion are new.

⁴Seq. Gottsche, *De Mexikanische Levermosser* (1863).

TABLE SHOWING DISTRIBUTION OF THE HEPATIC GENERA, *FRULLANIA* AND *PLAGIOTILA*.¹

NORTH AMERICA.		SOUTH AMERICA.		EUROPE.		ASIA. (Mostly from India.)		AFRICA. (Mostly Cape Colony.)		JAPAN.		AUSTRALIA.		NEW ZEALAND.		TASMANIA.		JIWA.		BORNEO.		SANDBWICH ISLANDS.		ISLES OF JINDIN OCEAN.		ATLANTIC ISLES.		PALEOLOGIC ISLES.									
North of Mexico.		Bolivia.		U. S. Colombia.		Chili.		Ecuador.		Guiana.		Paraguay.		Venezuela.		Peru.		Total.		Australia.		New Zealand.		Tasmania.		Jiwa.		Borneo.		Sandwich Islands.		Isles of Jindin Ocean.		Atlantic Isles.		Paleologic Isles.	
Mexico.		Brazil.		U. S. Colombia.		Chili.		Ecuador.		Guiana.		Paraguay.		Venezuela.		Peru.		Total.		Australia.		New Zealand.		Tasmania.		Jiwa.		Borneo.		Sandwich Islands.		Isles of Jindin Ocean.		Atlantic Isles.		Paleologic Isles.	
West Indies.		Colombia.		Colombia.		Chili.		Ecuador.		Guiana.		Paraguay.		Venezuela.		Peru.		Total.		Australia.		New Zealand.		Tasmania.		Jiwa.		Borneo.		Sandwich Islands.		Isles of Jindin Ocean.		Atlantic Isles.		Paleologic Isles.	
North of Mexico.		North of Mexico.		North of Mexico.		Chili.		Ecuador.		Guiana.		Paraguay.		Venezuela.		Peru.		Total.		Australia.		New Zealand.		Tasmania.		Jiwa.		Borneo.		Sandwich Islands.		Isles of Jindin Ocean.		Atlantic Isles.		Paleologic Isles.	
Frullania	21	29	19	8	39	15	10	23	12	3	2	23	6	79	8	15	14	12	6	11	23	4	9	6	6	6	13										
Plagiocochla	6	69	52	25	35	20	15	44	13	12	-	41	8	155	8	14	21	9	8	22	47	7	6	12	3	18											

¹ It should be noted that certain regions have been better worked than others, which will account for apparent anomalies. For the two genera North America may be considered as fairly represented. In South America the excess noted in Brazil, Ecuador and Peru, is due to the labors of Dr. Spruce. The excess in Java is due to the labors of Blume, Nees and Sande-Lacoste.

A few comparisons of the hepatic flora of the two continents will prove suggestive; we select only the larger genera.

COMPARISON OF HEPATIC FLORA OF EUROPE AND NORTH AMERICA.

GENERA.	EUROPE.	COMMON TO EUROPE AND AMERICA.	N. AMERICA. (NORTH OF MEXICO).	COMMON TO UNITED STATES AND MEXICO.	MEXICO.
Lejeunea.	14	4	28	1	83
Frullania.	8	2	21	3	29
Bazzania.	5	2	2	—	11
Plagiochila.	8	2	6	—	68
Scapania.	22	7	18	1	1
Porella.	7	5	9	2	15
Lophocolea.	10	4	7	1	8
Radula.	8	1	10	2	11
Cephalozia.	24	8	18	—	8
Jungermania.	68	19	85	3	16
Anthoceros.	4	2	12	2	5
Riccia.	20	9	20	1	2
Fimbriaria.	7	3	7	1	2

Aside from the dozen or more ubiquitous species, all of which are common in Europe, the species of North American Hepaticæ may be arranged in four floral regions or provinces. These were first outlined in our first venture at the study of our species¹ and further information has tended to strengthen the belief that they are fairly natural ones, with only such transitional forms as are common wherever lines are attempted on the face of Nature. These provinces are as follows:—

I. *Boreal*.—Including the cooler regions of North America from the latitude of Lake Superior northward, including Labrador, Alaska and Greenland, and extending southward on the higher mountains of New England and, so far as scanty information goes, the mountains of Colorado also. A small collection of Labrador species made by Prof. O. D. Allen shows a striking similarity with the species of the White Mountain flora, as do those from Gaspé, Quebec, communicated by the same collector. In this province occur principally species of *Scapania*, *Marsupella*, *Jungermania*, *Mylia* and *Gymnomitrium* with a few of *Frullania* and *Cephalozia*. The first-named genera are notoriously boreal, only one species of *Scapania* extending far southward and that one (*S. undulata*) appearing as far as the mountain region of Mexico. The great majority of the species are also inhabitants of Northern Europe and probably of Asia as well.

¹Descriptive Catalogue of North American Hepaticæ (1884), pp. 4, 5.

II. *Medial*.—This province includes the range of northern states from Nova Scotia and lower Ontario to the Rocky Mountains, extending southward to Arkansas and the Carolinas. From the fact that this province includes nearly all the portions of our country that have been most carefully studied, the number of species from this province is greatly in excess of others, including nearly half of our known flora. The range of genera is also very great, including all but seven of the fifty-three now known from the country.¹ The Marchantiaceæ and Ricciaceæ are especially well represented.

III. *Austral*.—This province includes the states bordering on the Gulf of Mexico, reaching northward along the lowlands of Georgia and South Carolina. A single trip of Mr. Austin and Capt. John Donnell Smith with a few collections by Dr. C. Mohr from the vicinity of Mobile, have furnished us nearly all the information we possess of this province,² and yet it is sufficient to indicate the existence of a striking flora, bearing, as might be expected, the marks of the West India region. Much may be expected from the swamps of Florida so soon as some one may be induced to collect the bryologic treasures of what ought to be one of the richest hepatic regions of the continent. Species of *Frullania*, *Lejeunea*, *Radula* and the southern types of *Plagiochila* and *Porella* are the characteristic forms, as well as *Dumontiera*, *Anthoceros*, *Sphaerocarpus* and the rare and peculiar *Thallocarpus*. More endemic species are found here than farther northward, yet there are interesting relations suggested with the flora of the Mediterranean region of the Old World.

IV. *Occidental*.—The Pacific coast region from San Diego to Alaska is included in this province. Our knowledge of it largely comes from the early collections made in the vicinity of San Francisco by Dr. Bolander and from the later and more extensive collections of Prof. John Macoun in British Columbia, which are still coming in. The indications here point to a rich flora throughout the whole region, localized and otherwise modified, especially in the southern portions, by the peculiar climate of the country as well as by the lack of dense forest growth. So far as known the species are very largely endemic and only toward the northern portion of the province do European species appear to any considerable extent. Characteristic of the region are the species of *Frullania*, *Radula*, *Lejeunea*,³ *Porella*, *Ptilidium*, *Scapania*, *Marsupella*, *Fimbriaria* and *Anthoceros*, while the three genera of Marchantiaceæ, *Targionia*, *Sauteria* and *Cryptomitrium*, are found in this province alone. With the single exception of Florida no region is less known, nor is any likely to be so productive as the region from Washington to Lower California.

To the above four provinces we must add a fifth.

V. *Mexican*.—This province so closely related to us, ought no longer

¹Plates illustrating forty-six genera appear in the sixth edition of Gray's Manual of Botany.

²Since the above was written we have received an extensive collection of Louisiana Hepaticæ from Rev. A. B. Langlois, which confirms many of these statements.

³*L. Macounii* Spruce n. sp.

to be divorced in our considerations of the flora of North America. To stop at a purely artificial boundary, as our works on botany have been perhaps forced to do, has been the cause of some unfortunate conclusions. Our knowledge of Mexican hepaticas is based largely on the collections of Liebmann and Karl Müller which were elaborated by Dr. Gottsche in his matchless *Mexikanske Levermosser*. The similarity of this flora to that of Bolivia and Chili has recently been pointed out by Dr. Spruce¹ and numerous species from this province are also found in the West Indies and other parts of meridional America. The excessive number of species of *Lejeunea* (88) and of *Plagiochila* (68) shows the near approach to tropical conditions, as does the increase of the southern forms of *Frullania*, *Radula*, *Porella* and *Bazzania*. The northern genera, *Cephalozia*, *Scapania* and *Marsupella* are scarcely found, *Scapania undulata* and *Marsupella Mexicana* appearing on the higher mountains, while the southern genera *Androcrypha*, *Isotachis*, *Monoclea*, *Symphyngyna* and others appear, that have not been found within the limits of the United States.

The vertical range of species has been an interesting problem since Spruce first made his studies in the Pyrenees in 1849.² Too little is known of our mountain flora to form either comparisons or conclusions. The White mountains alone, among the elevations of America, have been examined, and while these present many interesting problems, they are too insignificant to furnish many data for a general discussion. The Rocky mountains and the Sierras must be scaled by the bryologist before America can furnish her contribution to the problems of distribution in elevation, nor can we doubt that when that time shall come, the information will be of such a nature as to assist materially in solving many perplexing features connected with the subject.

THE MIGRATION OF WEEDS. By BYRON D. HALSTED, New Brunswick,
N. J.

THE migration of weeds is only one chapter in that great volume, yet mostly unwritten, the title of which may be the distribution of plants over the face of the earth; in other words it is but a single phase of that broad and comprehensive subject, namely: the wandering of plant offspring from the place of their birth.

It is well to bear in mind that the term weed is a relative one. If it please you, weeds sprang into existence in that shadowy morning of our race when man learned to distinguish good from evil and was cursed for his acquirements. Weeds are only plants that are able to assert their in-born rights above all others and wage a close warfare with man for the possession of the earth. There is nothing in structure, form or substance that distinguishes a weed from other plants. It lives, grows and repro-

¹ Memoirs Torrey Botanical Club, No. 3 (1890).

² Annals and Magazine of Natural History (Feb., 1849).

duces its kind like all others of its class and therefore the methods of migration are the same as obtain with those of its kin. The rapidity may be greater because of the dominant weed nature, but the difference is only in degree and not in kind. No new laws of distribution were born with the advent of the garden and cultivated field, but new and more favorable conditions only. We brand a plant a weed only when it pesters us. Some plants are worse pests than others. Those most troublesome in one locality may be least so in another. Many plants are very useful friends under certain circumstances and the bitterest of foes in others.

It is not within the compass of this paper to consider the relative demerits of weeds, but, assuming that certain ones are quite universally pestiferous, to show if possible what have been some of the advances such have made in their attempts to cover equally our portion of the earth.

As weeds exist only as man creates the conditions for them, it is natural to expect that the first plant pests in this country were in those localities where the virgin soil was first broken, and the last place to find a weed should likewise be in the wild lands only known to the savage hunter and his game. Other things remaining equal the older parts of our country should have the longest weed history if not the longest weed list.

A large number of our worst weeds came to us from foreign countries. Just how they emigrated in every case will never be known. Some came as legitimate freight; many were "stowaways." Some entered from border lands upon the wings of the wind, on river bosoms, in the stomachs of migrating birds, clinging to the hair of passing animals and a hundred other ways, besides by man himself. Into the New England soil and that south along the Atlantic seaboard the weed seeds first took root. Also, there our wild plants, of that region, with a strong weedy nature, developed into pests of the farm and garden. As civilized man moved westward the weeds followed him, reinforced by new native ones that soon vied with those of foreign blood. Not satisfied with this these natives of the interior ran back upon the trail and became new enemies to the older parts of our land.

The conditions favorable for the spreading of weeds have increased with the development of our country until now we are literally overrun. Weeds, usually as seeds, go and come in all directions, no less as tramps catching a ride upon each passing freight train than in cherished bouquets gathered by the wayside and tenderly cared for by transcontinental tourists in parlor cars. In evidence of this the following notes and observations gathered from many sources are condensed into the brief limits of the present paper. The time, and your patience, could easily be exhausted in simply naming the weeds that occupy more or less of American soil. It is therefore imperative that a few of the worst species be mentioned and for convenience these are treated in the order of the standard lists and manuals of the United States.

Only two of the several weedy plants of the *Ranunculaceæ* interest us particularly in this connection, namely: *Ranunculus acris* L. and *R. bulbosus*

L. Both are old and common Europeans in the eastern states, but I find no mention of them as yet on the Pacific coast. Both have been good illustrations of persistent invaders without any special structural adaptations for migration in seed or plant. They are met with abundantly in some localities and rarely in others from Minnesota to Ohio. The floras of Indiana (1881) and Kansas (1888), for example, do not contain them. *R. acris* has been the better traveller. Dr. Cooley noted its advent into Macomb Co., Mich., as early as June 11, 1845. Dr. Beal has watched, he informs me, its progress for twenty-three years. It is now in Shiawassee Co.

Papaver dubium L., a troublesome weed of Europe, has found a foothold in a few Atlantic states. Professor Rothrock writes me that within fifteen years he has seen it spread from Downington west almost to Lancaster, Pa., twenty-five miles, becoming each year more common. On the other hand *P. somniferum* L. is found in most of the middle states, due to the fact that it has escaped from cultivation.

In *Argemone Mexicana* L., we have a common and miserable weed of the southern states that has come up to us from tropical America and spread, although yet sparingly, over many of the northern states. The fact that it has been cultivated in gardens has helped its migrations, which now reach nearly to the ends of the earth.

Lepidium campestre (L.) R. Br. is one of the most interesting of the *Cruciferae* from the migratory point of view. While still marked as rare in the last edition of Gray's Manual, it is a troublesome weed in many localities where it has gained the mastery over large areas with remarkable rapidity. It is the most common weed in many fields near New Brunswick, N. J., in May. According to Professor Dudley it was first noticed in Ithaca, N. Y., in 1873. As this paper is being copied, Craig's catalogue of the uncultivated plants on the Ohio University grounds comes to hand and the following is quoted, "This weedy plant which is not given in Beardslee's catalogue of the plants of Ohio, is very abundant in the northeast corner of the woods-meadow where it is spreading rapidly. . . . It is one of our recently introduced plants. Six years ago there was scarcely any to be found there; it now covers the northern half of the field and is becoming common in other places." Professor Claypole reported a single clump of this plant in Summit Co., Ohio.

The three species of *Brassica*, namely, *B. alba* (L.) Boiss, *B. nigra* (L.) Koch, *B. arvense* (L.) B. S. P. (*B. sinapistrum* Boiss) and *Capsella Bursa-pastoris* (L.) Mœnch., need only be mentioned in passing as remarkable for the extent to which they have become naturalized. Nearly every flora, no matter how local, contains three at least of these four pestiferous plants.

Lychnis Githago (L.) Lam. is a conspicuous instance of a foreign weed that has become common to nearly all wheat growing regions of America excepting California (it is mentioned in Howell's catalogue of plants of Oregon, Washington and Idaho), and yet is not counted among the naturalized weeds. Dewey said in 1840 of this plant, "propagated with the wheat," and the same may be said of it to-day. Better care in cleaning

seed grain would do much toward reducing the damage done by corn cockle.

Sida spinosa L. illustrates the northward movement of a southern weed, the home of which was probably in the tropics. Found first in "dumps" around mills in New England, it is natural to infer that the seeds were brought north in baled cotton. It is now found occasionally in many of the central and western states. The *Abutilon Avicinnae* Gaertn. is another malvaceous plant which, first coming from India, is rapidly working its way toward the western coast. *Hibiscus trionum* L., taking advantage of its beauty and escaping from gardens, has become a great nuisance in many places and is to be expected anywhere east of the Rocky Mountains. *Malva borealis* Wallm., so luxuriant in neglected soil in California, has recently obtained a foothold near woollen mills in Massachusetts and illustrates how a weed may make a long move eastward through the unintentional assistance of man.

In like manner the *Erodium cicutarium* (L.) L'Her., whether a native of California, as Dr. Watson and some others believe, or introduced in the fleeces of the flocks from Spain,— while keeping pace with those flocks, has made a "permanent settlement," according to Mr. Collins, in the woollen mill yards of Massachusetts. While the alfalfa is a fine forage crop, it may be a most annoying pest and takes a high rank among the weed lists of some of my Californian correspondents. In the Leguminosæ *Medicago lupulina* L., *Melilotus alba* L. and *Lespedeza striata* Hook. and Arn. most interest us. The first two are from Europe and generally common but not aggressive in the eastern states. In the richer soil of the middle prairie region their growth is rank, as the following quotation from a good authority will show, "*Melilotus alba* L., introduced a few years ago as a garden plant, has spread so rapidly in the rich bottom lands along the Mississippi river that it is fast driving out the sunflower and other native weeds." The *Lespedeza*, or Japan clover, was accidentally introduced into South Carolina in about 1849 with imported goods, probably from China. It has spread with great rapidity through the south, and according to Dr. Neal it has become one of the aggressive weeds of Florida, holding the soil against all else. It has won high esteem with many as a forage plant, much to its credit. However, it has great weed possibilities and is a remarkable traveller.

Of the Umbellifers only two can be named here: *Daucus carota* L. and *Pastinaca sativa* L., both naturalized from Europe long ago in the eastern states, and year by year have made a steady progress towards the Rocky Mountains. Sometimes in the middle states the wild carrot is reported as the more abundant and in other places the wild parsnip is the worse. The carrot has been most aggressive in the Atlantic states, and J. J. Thomas, who has kept notes of weed plants for fifty years, writes me that it has increased greatly of late in Central New York. It is persistent as well as progressive. That the parsnip has now a wider range than the carrot may be due to the former straying from the garden and quickly degenerating into the wild pest. Thus both species are absent from the flora of Cali-

fornia (1880), but S. B. Parish, a keen observer, found the first wild form of the parsnip in his state (California) in 1882 upon a stream bank below a farm house and since then the weed has spread rapidly. The carrot travels well in baled hay.

In the Compositæ we find many weeds, the worst of which, and the worst of all, is *Cnicus arvensis* (L.) Hoff.; while generally to be found in the Atlantic states it seems not to have obtained a stand in California. In many of the middle western states, as Michigan, Wisconsin and Kentucky, it has been upon the increase for twenty or more years and is becoming a pest beyond the Mississippi. Sometimes it has been introduced to new localities in the packing hay and straw of merchants' goods, but more frequently in unclean seed of field and garden crops. Its methods of spreading when once established are well known to all. *Chrysanthemum Leucanthemum* L. is another standard nuisance of European origin in the eastern states and is now not unknown to the Pacific coast. In the Mississippi Valley it does not seem to be a successful rival with some of its relatives, and while widespread it has not acquired the courage manifest in the Atlantic states. Botanists and others claim that it does not seed well on the prairies. It offers a good illustration of weed migration in the seed condition, mixed with timothy, red top and other grass seed, from which it is not quickly detected. Its being distasteful to live stock helps it in holding the soil when once established. The Xanthiumns furnish illustrations of a variety of movements. *X. Canadense* Mill, as a native of the central southern states, has spread north, east and west until it is in Minnesota, New York, California and Idaho. The variety *echinatum* (Murr.) Gray has extended throughout New England and is by no means confined to the "sandy sea shore and on the great lakes" of the Synoptical Flora. *X. strumarium* L., from Europe, meets its cousin, *X. spinosum* L., from tropical America and both may be seen, for example, in Massachusetts, New Jersey, Kansas and California. These two rank pests with hooked seed coverings well adapted for catching into wool, invade a vast country from widely separated points and will finally cover it.

According to Professor Blatchley, *Hypochaeris radicata* L. appeared in Indiana not long ago and its advent was clearly traced to the packing surrounding some goods from Germany. It is an occasional ballast plant at New York and Philadelphia.

Lactuca scariola L., while yet not among the worst weeds, partly because rare, has of late years manifested a remarkable tendency to spread throughout the country. Judge Day saw it forty miles west of Milwaukee in 1880. According to Professor Claypole it is a new comer to Summit Co., Ohio, where in the last four years it has increased rapidly. I saw it at Cleveland while at the meeting of this Association, and it is becoming common in the vacant lots of Chicago. Professor Pammel found it on refuse heaps of nursery packing near La Crosse, Wisconsin, in 1887, and recently in northern Texas and several places in Missouri. It shows a peculiar preference for neglected streets and grounds of cities and thus keeps close to the lines of railway, by which it undoubtedly travels.

Artemisia biennis Willd., a native westerner, is one of the recent introductions to the east. Judge Day writes me that it is abundant around Buffalo, N. Y., but has become so within the past few years. It is also common near Boston, Mass., and has increased rapidly of late according to Dr. Swan. Gray's manual for 1856 said for range of this species, "Ohio and westward;" in 1875 edition, "rapidly extending eastward," and the Synoptical Flora (1884) "now spreading to the seaboard." A still more aggressive weed from the west is *Rudbeckia hirta* L., now marked "common" in the floras of the eastern states. Professor Rothrock writes that in Maine, from Bangor to Moosehead lake, it was much more abundant than in any other place known to him. T. H. Hoskins, Newport, Vt., writes that it was quite unknown at his place twenty-three years ago, but is now abundant, and adds that it came in western clover seed. According to Professor Eaton it was rare at New Haven thirty years ago. T. S. Gold, secretary of board of agriculture for Connecticut, also writes, stating that it came in grass seed from Illinois thirty years ago. The cone flower is more than a fair exchange for the ox-eye daisy that has less steadily and successfully established itself in the west. The last vagrant of the Compositæ, and the last in this order, space will permit of mention here, is what Prof. W. W. Bailey styles a "lovely pest," namely, *Hieracium aurantiacum* L., which on account of its beauty had been given a place in flower gardens, only to gather strength and take advantage of its admirers. It is a prominent weed of the later days and calls for more replies to the question, "What new weed is this?" than all others. The Cayuga Flora says, "In 1885 a few specimens were found." Professor Eaton writes that it is spreading through Connecticut, while others report it as abundant in Vermont and Maine.

Echium vulgare L. is a vile weed that is increasing in numbers and widening its territory in the eastern states. Professor Rothrock writes me that twenty years ago it was almost unknown in Mifflin Co., Pa., but now has taken possession of all abandoned spots "from the river clear up to the slope of the mountain." First noticed by E. Volk at Trenton, N. J., in 1878, it is now abundant. Professor Bailey writes for Rhode Island, "Increasing to an alarming extent." This species is mentioned particularly as one that seems to be satisfied with the Atlantic states and is not moving westward with a dangerous pace. Its near neighbor, also from Europe, *Lithospermum arvense* L., while much more modest in appearance, is far the greater traveller, and figures in the grain fields both east and west. The reason for the difference may reside in this fact, thus insuring the spread of the pest in the seed grain, while the burly bugloss grows mostly in neglected land. Dr. E. F. Smith mentions the puccoon in particular as having been spread in Michigan by the itinerant threshing machine.

Convolvulus arvensis L. is a beautiful, bad weed now quite old to the eastern states, but is finding its way westward and working harm in many places. The latest catalogue to date from the central western region gives what has been gathered from several other sources, namely, "this plant was recently introduced and . . . is spreading rapidly." I found but a single patch of it while at Ames, Iowa, introduced it is thought in wheat.

Two of the foreign dodders are good instances of the introduction of weeds of the worst sort, namely, *Cuscuta Epilinum* Weihe, of the flax, and *C. epithymum* Murr., quite troublesome in some quarters upon the clover. Being parasites they must rise or fall with the increase or abandonment of their respective hosts, and may be expected at any place where the seed sown contains the germs of these dodders.

In *Solanum Carolinense* L. we have a southern native that has slowly and surely extended northward until its range in the new manual is given as "Conn. to Iowa south to Fl. and Tex." It is particularly obnoxious in Kansas, from which state it has been reported by several parties. This species only prepares the mind for another of the same genus—a most execrable pest from which all who possess it may well pray to be delivered. This is *S. rostratum* Dun., which is contributed to the cultivated lands of our country by the plains of Nebraska and Texas. Gray's manual (1890) says, "spreading eastward to Ill. and Tenn." To those who know by experience the hateful nature of this vagabond this is far enough, but in the recent Flora of New Jersey Dr. Britton lists it from three counties and calls it naturally "a fugitive from the west." Turning to the herbarium I find the same prickly, defiant nuisance that was beginning to curse the fields at Ames, Iowa, three years ago. Collins gives it in his Middlesex (Mass.) Flora, and it has been reported from New York. It becomes a tumble-weed, thus adding a seed-spreading power to its long list of detestable qualities.

The *Linaria vulgaris* Mill. is a superior illustration of a weed in itself handsome and harmless to the touch, gaining a hearty introduction into American gardens. But it roots deeply, seeds heavily, and holding the soil it has, it spreads to new areas above ground and below, and the seeds are well adapted in size and color to become undetected foul stuff in clover and grass seed. Several western farmers have reported to me that this nuisance came to them in the packing of goods from the east.

Phelippea ramosa L. is a comparatively new and severe parasite upon hemp and tobacco, that probably came from China with hemp seed. It is particularly bad in Kentucky and Professor Carman has recently issued an illustrated bulletin upon the subject, with proper advice as to methods of checking the spread of the pest.

The plantains furnish some interesting points in migration. *Plantago major* L. is almost literally everywhere, following as it does, with remarkable promptness, upon the heels of the pioneer, it soon becomes a dreaded pasture and meadow weed in many places. *P. lanceolata* L. is likewise to be expected in any state or local flora, but its wanderings are less difficult to account for, as in many instances the seed has been purposely sown for sheep pasturage; besides the seeds are of a size, shape and color to easily go mixed with those of clover, its most common vehicle of migration. *P. Patagonica* var. *aristata* Gray, unlike the others, is doubtless native (*P. major* is considered by some as both native and introduced from Europe) of the west, and has of late years become a settled occupant of the fields of New England and the states found on its way to the Atlantic.

During the past year the *Salsola Kali* L. has as a weed attracted special

notice. It has been sent to me from a number of parties in Dakota and from the reports it appeared as if it might have been brought into that region with the goods of Russian or other settlers. From this supposed fact it took the common name of "Russian cactus." Dr. Bessey reports it from northern Nebraska and Mr. Hitchcock found it quite abundant at one place in Iowa, along the railroad that extends to Yankton, Dak. Mr. Cratty reports it in two other localities in northern Iowa (Emmet Co.), where, as in the Russian settlements in Dakota, it was a tumble-weed. Dr. Watson thinks it may be native to the region of Dakota. However this may be, the plant is associated in the botanical mind with sandy sea shores, and more than all it is a direful weed that is reported as forming balls as large as houses and rolling with the wind for long distances over the prairies, leaving no excuse for its not spreading rapidly.

Allium vineale L. is one of the vilest of pasture and lawn weeds in the east, but is not generally found in the west. Professor Scribner reports it as a nuisance in Tennessee, and Professor Lazenby ranks it in the third class of weeds for Ohio. Propagation is largely by bulbs and its migration will be slow. One method of getting from one place to another was observed by Thos. Meehan, namely, by the dried leaves catching in the passing lawn mower, when the bulb is uprooted and carried forward indefinitely.

A few of the weed grasses are fair travellers. *Agropyrum repens* (L.) Beauv., in one or more of its puzzling forms, is found nearly the country over, but is not the bad weed in the south that it is at the north. There is no mystery why this plant with its subterranean stems should hold all good soil it is in. It migrates from one part of the field to another upon the plow and harrow and across states in hay, hay packing and foul stuff in grass, grain and other seeds. *Hordeum jubatum* L. is a western grass, very abundant in Nebraska, according to Dr. Bessey, a prominent pest in Wisconsin meadows, as reported by Professor Henry, and moving eastward, rapidly along railroad tracks in particular. I saw it more than double its strength in Iowa in four years, and if the writer had accepted the offers of eastern florists for a large quantity of the heads for decorative purposes, might have assisted materially in the spreading of the pest. It is, however, found in some of the eastern states and may soon rival another new comer of the grass tribe, namely, *Bromus tectorum* L. from Europe, which as yet I have not heard of west of New York and Pennsylvania. It was first observed at New Haven, about wharves, in 1872, and is now abundant there. According to Mr. Manning it reached Boston in 1883 and is now spreading rapidly, and is common in several localities in Middlesex county, as reported by Dr. Swan. It is the most common early grass in dry, waste places here in New Brunswick. The *Bromus secalinus* L. goes wherever wheat and rye are cultivated and with the seed of those grains. *Cynodon Dactylon* (L.) Pers., so highly prized in the south for pasturage, is becoming a nuisance, especially in lawns, in the northern states. It is reported as a miserable weed in Tennessee, and within a week my attention has been called to it in this state, where its creeping stems invade the

sandy soil of South Jersey. A four-foot string of it now hangs upon my laboratory wall, where it may die. The owner of the infested land in question is quite certain that the pest started from a dump heap that received hay packing from boxes. In *Cenchrus tribuloides* L. we have a vile weed native to many sandy places along lakes and streams from the Atlantic to the Pacific coast. Its migrations, therefore, have been largely from these wild haunts to the fields and gardens. This has been very general, as is to be expected as the seeds are well provided with a method of clinging to passing animals, as many boys well know.

Time fails me, or otherwise the movements of scores of other weeds might be mentioned. Something could be said of the hundreds of ballast plants that are constantly coming to our shores, most of which fail to gain a foothold. This suggests that the majority of our foreign plant foes are already within our borders. However, there are enough for all, and there may be weed possibilities in some of our native species that will add to the present burdens upon American agriculture. The importance of knowing as far as possible the nature of these intruders at the outset is clear to all, and that they should be eradicated when young in experience and weak in numbers is self evident.

It is not necessary, in closing, to dwell upon the pleasures that botanists take in watching for the advent of new weeds and the increase or decrease of old ones, or urge them to make their observations known to crop growers, fellow botanists and others. In conclusion I wish to thank all who have extended a helping hand in the preparation of this exceedingly incomplete paper.

New Brunswick, N. J., Aug. 14, 1890.

GEOGRAPHICAL DISTRIBUTION OF THE GRASSES OF NORTH AMERICA. By
Dr. W. J. BEAL, Agricultural College, Ingham Co., Mich.

GRASSES are very widely distributed over the earth's surface. The species are most numerous in tropical regions, where the plants are usually scattered, while in a moist, temperate climate, though the species are less numerous, the number of plants is enormous, often clothing vast areas and open places with a close growth. In temperate regions where sufficient moisture is wanting to sustain a dense growth, the grasses appear in tufts or bunches more or less isolated.

The species of grasses of many parts of North America have not yet been sufficiently studied to enable any one to outline with much precision their distribution. This is partly owing to the difficulty of the subject and partly to the lack of thorough exploration in the newer sections, especially in Mexico and countries to the south.

In the *Genera Plantarum* of Bentham and Hooker, the genera of Gramineæ have been recorded at 298; the species at the highest, about 3,200.

The number of genera is now known to be a little larger and the number of species discovered has increased considerably.

Many botanists are inclined to separate grasses into more genera and more species than have the authors of the standard work above mentioned.

The number of genera native to North America, including the West Indies, so far as discovered and described is about 186.

The number of genera introduced, mostly as weeds, 25.

The number of species native to North America about 1,257.

The number introduced as weeds, etc., about 105.

The whole number of genera, 161.

The whole number of species now known here, 1,862.

No doubt there are still a considerable number of native southern species especially, yet to be discovered, and some others will ere long find a home as emigrants from foreign lands.

The lists of grasses to be found in Asia, Africa and South America are too imperfectly known to be mentioned here.

For Europe we are more fortunate in having the excellent *Conspectus of C. F. Nyman*, published in 1882. According to Nyman, the number of genera of grasses in Europe is 47; the number of species, 570.

In 1877 was published Bentham's *Flora Australiensis*. In this work, the author records the number of genera of grasses, native and exotic, as 41; the species as 388.

In these enumerations, it must be remembered that the European report is the more recent, that the grasses of Europe have been the more thoroughly studied, and that Nyman makes more species than would Mr. Bentham in the same territory. No doubt by this time a considerable number of species have been added to that given by Bentham in his Australian Flora.

Most likely the various persons who have from time to time described the grasses found on this continent have made many more species, and some more genera, than Mr. Bentham would have done, and we are using his list as our standard in comparing the grasses of these countries. Even with these explanations, the reader must understand that the figures here given are somewhat misleading, and in favor of North America.

In the following list I include the species introduced and established, as well as those which are endemic.

In a survey of the whole world, there are at least twenty-four genera of grasses containing each thirty or more species, viz.:

	SPECIES.	IN N. A.	PER CENT. OF ALL IN N. A.
Panicum	250	171	68
Paspalum	160	74	46
Andropogon (<i>Chrysopogon</i>) (<i>Heteropogon</i>) . . .	180	59	45
Deyeuxia (Calamagrostis in part) . . .	120	31	28
Agrostis	105	37	35
Aristida	100	51	51
Eragrostis	100	38	38
Stipa	100	31	31
Danthonia	100	5	5
Muhlenbergia	89	78	85
Poa	80	58	73
Sporobolus	80	47	59
Festuca	80	48	57
Trisetum	50	18	36
Setaria	42	40	95
Bromus	40	27	67
Pennisetum	40	18	42
Chloris	40	17	42
Avena	40	11	27
Bouteloua	30	80	100
Melica	30	20	67
Glyceria	30	16	53
Chusquea	30	8	27
Ischænum	30	1	3

Of genera of medium or small size, containing from 6-24 species each, the following are named, viz.:

	SPECIES.	IN N. A.	PER CENT OF ALL IN N. A.
Oryzopsis	24	10	40
Arundinaria	24	4	17
Arundinella	24	4	17
Bambusa	24	2	8

	SPECIES.	IN N. A.	PER CENT. OF ALL IN N. A.
<i>Cenchrus</i>	30	19	95
<i>Elymus</i>	20	18	90
<i>Triodia</i>	20	14	70
<i>Agropyrum</i>	20	12	60
<i>Deschampsia</i>	20	12	60
<i>Alopecurus</i>	20	7	35
<i>Eriochloa</i>	20	7	35
<i>Ichnanthus</i>	20	7	35
<i>Pappophorum</i>	20	6	30
<i>Olyra</i>	20	4	20
<i>Isachne</i>	20	3	15
<i>Rottboellia</i>	18	8	17
<i>Oplismenus</i>	16	16	100
<i>Epicampes</i>	16	13	81
<i>Gaudea</i>	15	6	40
<i>Leptochloa</i>	14	10	71
<i>Diplachne</i>	14	8	57
<i>Hordeum</i>	12	8	41
<i>Arthrostylidium</i>	12	3	25
<i>Elionurus</i>	12	3	25
<i>Erianthus</i>	12	3	25
<i>Saccharum</i>	12	2	17
<i>Koeleria</i>	12	1	8
<i>Trachypogon</i>	11	3	27
<i>Polypogon</i>	10	5	50
<i>Phalaris</i>	10	5	50
<i>Briza</i>	10	4	40
<i>Colpodium</i>	10	2	20
<i>Phleum</i>	10	2	20
<i>Pariana</i>	10	1	10
<i>Spartina</i>	8	6	75
<i>Hierochloa</i>	8	4	52
<i>Graphephorum</i>	8	3	37
<i>Heleochoea</i>	8	2	25
<i>Ctenium</i>	7	3	43

	SPECIES.	IN N. A.	PER CENT. OF ALL IN N. A.
<i>Eleusine</i>	7	3	43
<i>Brachypodium</i>	6	3	50
<i>Eatonia</i>	6	6	100
<i>Gymnopogon</i>	6	5	83
<i>Zeugites</i>	6	5	83
<i>Hilaria</i>	6	4	66
<i>Lepturus</i>	6	3	33
<i>Luziola</i>	6	2	33
<i>Milium</i>	6	1	17
<i>Leersia</i>	5	5	100
<i>Distichlis</i>	5	3	60
<i>Trichloris</i>	5	3	60
<i>Pharus</i>	5	2	40
<i>Arthophora</i>	5	1	20
<i>Oryza</i>	5	1	20
<i>Platonia</i>	5	1	20
<i>Ammophila</i>	4	4	100
<i>Tripsacum</i>	4	4	100
<i>Uniola</i>	4	4	100
<i>Imperata</i>	4	3	75
<i>Scleropogon</i>	4	3	50
<i>Munroa</i>	4	1	25
<i>Reimaria</i>	4	1	25
<i>Ægopogon</i>	3	3	100
<i>Anthænanthia</i>	3	3	100
<i>Cathestechum</i>	3	3	100
<i>Chætium</i>	3	3	100
<i>Cinna</i>	3	3	100
<i>Euchlæna</i>	3	3	100
<i>Triplaspis</i>	3	3	100
<i>Asprella</i>	3	2	67
<i>Disanthelium</i>	3	2	67
<i>Pleuropogon</i>	3	2	67
<i>Gynericum</i>	3	1	33
<i>Hemarthria</i>	3	1	33

	SPECIES.	IN N. A.	PER. CENT. OF ALL IN N. A.
Amphicarpum	2	2	100
Bealia	2	2	100
Eremochloa	2	2	100
Eriocoma	2	2	100
Orcuttia	2	2	100
Orthoclada	2	2	100
Thurberia	2	2	100
Zizania	2	2	100
Diarrhena	2	1	50
Phragmites	2	1	50

The following genera of one species only each are found in North America and elsewhere: *Catabrosa*, *Coleanthus*, *Cottea*, *Phippia*.

The following genera contain one species each, which is limited to North America: *Bauchea*, *Brachyelytrum*, *Buchloë*, *Calamachloa*, *Hydrochloa*, *Jouvea*, *Monanthonchloe*, *Opizia*, *Rachidospermum*, *Redfieldia*, *Reynadia*, *Schaffniera*, *Schedonnardus*, *Scribnaria*, *Zea*.

The following species found in North America are very widely distributed elsewhere, viz.:

- Agrostis scabra*, Willd. Cool N. A. and Australia.
- Andropogon contortus*. Trop. and Subtrop. Am. As., Afr., Aust.
- Arctagrostis latifolia*, Gris. Arctic Asia, Europe and N. A.
- Beckmannia eruciformis*, Host. Temp. Eu., Temp. Asia, West, N. A.
- Catabrosa aquatica*, Beauv. Temp. Eu. Asia, N. A.
- Cenchrus tribuloides*, L. N. A., S. A., Asia, Africa.
- Coleanthus subtilis*, Seid.
- Cottea pappophoroidea*, Kunth.
- Deschampsia cespitosa*, Beauv. Temp. and cool regions of the world.
- Distichlis maritima*, Raf. Seacoast of America and Australia.
- Eragrostis ciliaris*, Link. N. A., S. A., East Indies, Africa.
- Eragrostis reptans*, Nees. N. A., S. A.
- Festuca ovina*, L. Temp. regions of the world.
- Glyceria fluitans*, R. Br. Temp. and cool N. Hem. and Aust.
- Hierochloa alpina*, R. & S. Cold N. Hemis.
- Hierochloa borealis*, R. & S. Cold and Temp. N. Hemis.
- Koeleria cristata*, Pers. Temp. and Subtrop. N. Hemis. and Aust.
- Leersia hexandra*, Swz. S. E. N. A. to Buenos Ayres, Afr., Aust., East Indies.
- Lycurus phleoides*, H. B. K.
- Manisurus granularis*, Swz. All tropical regions.

Panicum capillare, L. All cool and warm regions.

Panicum Crus-galli, L. All cool and warm regions.

Panicum colonum, L. Most warm and tropical regions.

Panicum prostratum, Lam. Most warm and tropical regions.

Paspalum conjugatum, Borg. Warm parts of N. A., S. A., Aust., Afr.

Paspalum distichum, L. Warm parts of N. A., S. A., Aust., Afr.

Phippia algida, R. Br.

Spartina cynosuroides, Willd.

Spartina polystachya, Willd. } New England to Rocky Mts.

Spartina stricta, Roth.

Sporobolus Virginicus, Kth. All warm regions.

Setaria glauca, Beauv. All Temp. and Trop. regions.

Tragus racemosus, Hall.

Trisetum subspicatum, Beauv. Temp. and cool N. A. and Aust.

The following species of North America are confined to limited areas, viz.:

Amphicarpum Floridanum, Fla.

Andropogon arctatus, Chap.

" *brachystachyus*, Chap.

" *gracilis*, Spreng.

" *longiberbis*, Hack.

Eriochloa mollis, Kth. Fla.

Leersia monarda, Swz. Fla.

Lusiola Alabamensis, Chap. Ala.

Eriochloa Lemmonii, V. & S. Arizona.

Hilaria rigida, Vasey. Arizona.

Phalaris Lemmonii, Vasey. Arizona.

Orcuttia Californica, Vasey. South Calif.

" *Greenii*, Vasey. Calif.

Rachidospermum Mexicanum, Vasey.

Lower Calif.

Untiola Palmeri, Vasey. Mouth of Colorado river.

Aristida Floridana, Vasey. Fla.

" *gyras*, Chap. Fla.

" *Jonesii*, Vasey. Arizona.

" *Orcuttiana*, Vasey. Arizona.

" *Palmeri*, Vasey. Arizona.

" *palustris*, Vasey. Fla.

" *scabra*, Chap. Fla.

" *simplicifolia*. Fla.

" *spiciformis*, Ell. Fla.

Ninety genera are represented by species in both hemispheres.

In comparing some of the genera of Europe with some of those of North America, we find that:

Europe has 40 species of *Avena*; North America has 11 species.

"	"	28	"	"	<i>Festuca</i> ;	"	"	"	46	"
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"	"	12	"	"	<i>Kaeleria</i> ;	"	"	"	1	"
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"	"	9	"	"	<i>Phleum</i> ;	"	"	"	1	"
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North America has 171 species of *Panicum*; Europe has 6 species.

"	"	"	76	"	<i>Muhlenbergia</i> ;	"	"	"	0	"
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"	"	"	74	"	<i>Paspalum</i> ;	"	"	"	0	"
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"	"	"	47	"	<i>Sporobolus</i> ;	"	"	"	1	"
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"	"	"	59	"	<i>Andropogon</i> ;	"	"	"	7	"
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"	"	"	51	"	<i>Aristida</i> ;	"	"	"	1	"
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"	"	"	88	"	<i>Eragrostis</i> ;	"	"	"	5	"
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"	"	"	80	"	<i>Bouteloua</i> ;	"	"	"	0	"
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"	"	"	14	"	<i>Triodia</i> ;	"	"	"	0	"
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"	"	"	10	"	<i>Oryzopsis</i> ;	"	"	"	0	"
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One species each of four small, though conspicuous European genera are cultivated in North America, viz.: *Anthoxanthum*, *Arrhenatherum*, *Dactylis*, *Lolium*.

In comparing some of the genera of Australia with some of those of North America, we find that Australia has no large genus of grasses not represented in North America, though that country has a few genera of medium size and many of a small size not represented in this country.

Australia has 0 species of *Muhlenbergia*; North America has 76 species.

"	"	0	"	<i>Bouteloua</i> ;	"	"	"	30	"
"	"	0	"	<i>Oryzopsis</i> ;	"	"	"	10	"
"	"	0	"	<i>Hilaria</i> ;	"	"	"	6	"
"	"	0	"	<i>Spartina</i> ;	"	"	"	6	"
"	"	1	"	<i>Deschampsia</i> ;	"	"	"	12	"
"	"	8	"	<i>Festuca</i> ;	"	"	"	46	"
"	"	8	"	<i>Agrostis</i> ;	"	"	"	37	"
"	"	4	"	<i>Paspalum</i> ;	"	"	"	74	"
"	"	6	"	<i>Sporobolus</i> ;	"	"	"	47	"
"	"	8	"	<i>Poa</i> ;	"	"	"	63	"

North America, as would be expected from its extent and configuration, has a greater number and variety of grasses than Europe, and Europe a greater number and variety than Australia. Europe lacks many of the species found in tropical and subtropical North America and Australia. North America compares favorably with both Europe and Australia combined. In the north of North America are species of European genera; in the south, species of many of the Australian genera.

CENTERS OF CERTAIN LARGE GENERA, SO FAR AS NORTH AMERICA IS CONCERNED:—

Agrostis. Cool west N. A.

Andropogon. East of Rocky mountains in warm states.

Aristida. East of Rocky mountains in warm states.

Bouteloua. Arizona and Texas.

Bromus. Cool west N. A.

Eragrostis. Warm east N. A.

Melica. Pacific coast to Rocky mountains.

Muhlenbergia. Arizona and N. Mex.

Panicum. Warm southeastern N. A.

Paspalum. Warm southeastern N. A., especially Fla.

Poa. Cool regions of west N. A.

Sporobolus. Warm regions of west N. A.

Stipa. Warm regions of west N. A.

GEOGRAPHICAL DISTRIBUTION OF NORTH AMERICAN CORNACEÆ. By Prof. JOHN M. COULTER, Crawfordsville, Ind.

THE Cornaceæ of North America are considered to include three very dissimilar genera, so dissimilar, in fact, that their geographical distribution must be considered independently. They seem to be so little related in origin, that their combined distribution can mean nothing.

The genus *Garrya* is a peculiarly American product, its affinities being so obscure that it would be very uncertain to speak of its origin. We only know that its present greatest display is in the Mexican mountains, and that its occurrence within the United States expresses the northward extension of a Mexican biological province. Of some eight or ten species recorded, the United States is known to contain six, and some of these are thought to be local, but very little weight can be given to these figures in the absence of a thorough knowledge of the Mexican flora. The genus extends into the mountains of extreme western Texas, is naturally found in New Mexico and Arizona, has reached northward a little into the Great Basin region in southern Utah and southern Nevada, and has made its most northerly prolongation in the Pacific States, one species extending even to the Columbia river. This is very exceptional, however, and the massing of *Garryas* is fairly along our Mexican border. To my mind, the chief biological interest of this genus to us, just now, is the fact of its helping to clearly define the northward extension of what is known as the Sonoran biological province, and from this view of the case, it hints to us of a distinctly Mexican origin.

The genus *Nyssa* is as clearly eastern as *Garrya* is southwestern, and is one of those genera that have divided their species between eastern North America and eastern Asia. The *Nyssas* of the eastern Himalayas and the Malay islands are fairly well paralleled by those of our Atlantic States. This has been taken to represent former high latitude connection, migration southward into suitable conditions, and the working out of continental divergences. The fact that these species are lovers of greater warmth than many that have come from the north has located them unusually far south in both continents, our four species all belonging to the South Atlantic and Gulf States, only one of them extending into the North Atlantic States. A case of remarkably local distribution is furnished by the curious *Nyssa Ogeche*, which is confined to the swampy grounds which extend from the southeastern edge of South Carolina through the Ogeechee valley of Georgia, and into the northern edge of Florida. The fact that these species all affect swampy ground, and even grow in deep swamps, may serve to make consistent their former high latitude occurrence and their present warm temperate distribution.

The largest genus, however, as well as one presenting some most interesting features in geographical distribution, is *Cornus*. The northern origin of this genus is incontestable, for species closely related to modern forms, not only that, but representing all the prominent subdivisions of the genus, have been taken from the Tertiary strata of the extreme north in both hemispheres. The consequence is that Europe and temperate Asia and America display about twenty-five species of *Cornus*, some seventeen of which are American. The result of the distribution in America is interesting. Three groups should be considered separately, for they were quite distinct, even in Tertiary times.

The conspicuously involucrate forms are represented by three herbaceous and two shrubby or arborescent species. The herbaceous species are still essentially high northern, extending into the U. S. only in the north-

ern tier of Atlantic States, and further south along the lofty mountain ranges of the west. But their home is throughout British America and to the Arctic Sea. These three species are so closely related that they need not be considered separately in geographical distribution, in fact the existence of one of them is very problematical. The arborescent species which ranged across tertiary British America has migrated so far southward as to have had its northern connection destroyed, and exists now as two representative species, one in the Atlantic States, the other in the Pacific States, species which have most evidently been made distinct from one another by separation.

The second group, represented by our very local *Cornus sessilis*, once had a world-wide high-latitude distribution, but is known now by only three species, two very common ones (*C. mas* and *C. officinalis*) in the Old World, and one in America, which has found a very restricted range and a precarious existence in the wet ravines and foot-hills of northern California. This species represents for us, therefore, a lingering remnant of a once very prominent group, a group that is surviving much better in Europe.

This by no means represents the fate of the third and most numerous group, the non-involucrate species, which have secured a strong hold upon all of the United States excepting the arid western plains.

This is an illustration of a group in which there is a single overwhelmingly dominant form, to which all others are related, and from which all others seem to have been separated. *Cornus stolonifera* is a species which in a graphic scheme of classification should have points of contact with every other non-involucrate species, a species which has the greatest possible range of characters, characters which seem to have become invariable in the other species, and in addition to all this it is the only one with a continental distribution, touching all the others not only in characters but in range.

The Great Plains form such a complete barrier that there are two great lines of *Cornus*, an eastern and a western, with no connection whatever, and showing several instances of parallel or representative species. But *C. stolonifera* is in both regions and has a complete overarching connection through the British possessions. It seems to represent an unresolved nebulous mass of characters, out of which certain forms of definite outline have been worked, or perhaps a more biological form of statement would be to say that it most nearly represents the primitive undifferentiated forms of this group of *Cornus*. This will help explain the fact that almost every non-involucrate *Cornus* has at one time or another been called *C. stolonifera*. A species which seems to have been separated from *C. stolonifera* in its extension from the Great Lakes to the Rocky Mountains, and which hence enjoys with it the distinction of touching both the eastern and western *Cornus* provinces, is the recently distinguished *C. Baileyi*. It is only in the South Atlantic States that the wide ranging of *C. stolonifera* is interrupted, but it is replaced there by such closely representative species that the interruption hardly counts. It does indicate, though,

that *C. stolonifera* cannot extend into very warm regions, a fact still further substantiated by its wide range in British America and its western occurrence only in the mountain ranges. The remaining eight species of the group are exactly divided between the Atlantic and Pacific States with this difference, however, that the eastern species are of much wider ranges and are much better established. The dominant western type is *C. pubescens*, which ranges throughout the Pacific States and frequently gives evidence of its separation from *C. stolonifera*. From *C. pubescens* have apparently been separated two very local and very poorly known species, *C. Torreyi* of the Yosemite region, and *C. Greenei* from some unknown California station, both of them collected but once. *C. pubescens*, with these two very small and obscure satellites, *C. Torreyi* and *C. Greenei*, are represented on the Atlantic side of the continent by such vigorous species as *C. sericea* and *C. asperifolia*, both ranging throughout the whole Atlantic State region, and *C. circinata* of the North Atlantic region. The fact is, the relation between *C. pubescens* and *C. sericea* becomes strikingly evident in some cases. The fourth Pacific species is *C. glabrata*, more restricted than *C. pubescens*, being confined to the coast ranges from central California to southern Oregon, but remarkably paired off with the Atlantic *C. candidissima*, which ranges through the whole Atlantic region. The fact is, Mr. Evans and myself, in our revision of this genus, had become afraid that the station would be only the certain means of distinguishing between *C. candidissima* and *C. glabrata*, until certain stone characters came to our aid.

A summary with regard to the genus *Cornus* is as follows:

During the Tertiary the genus had a continent-wide distribution in high-latitudes; when compelled and permitted to spread southwards it was divided into two widely separated regions by the Great Plains; the result has been a remarkable series of parallel species on the two sides of the continent, with permanent and vigorous results decidedly on the side of the Atlantic species; at least three of the Pacific species have become very local and one or two of them possibly extinct; the primitive undifferentiated forms are represented to-day by *C. stolonifera*, which touches every other species of its group both in specific characters and range.

ON THE GENERAL GEOGRAPHICAL DISTRIBUTION OF NORTH AMERICAN PLANTS. By N. L. BRITTON, Columbia College, New York, N. Y.

In order to obtain data from which valuable general considerations may be drawn concerning the relations of the floras of different regions to each other and the probable genesis of these floras, we must deal with the facts at hand in their broadest significance. It will not be satisfactory to reach conclusions from the known distribution of a single species nor of a hundred species although these may be suggestive. To arrive at the most valuable results we should know, accurately, the range of all native species

and it is, perhaps, needless for me to state that these facts are not all in. Enough may be however at hand to enable me to indicate some of the conclusions which shall be reached when more are obtained.

With these considerations in mind I have determined to restrict my discussion of the subject for the most part to the natural orders of plants as recognized in Bentham and Hooker's "Genera Plantarum."

Temperature, rainfall, soil, are the main factors which determine the floral characters of a region. The first two are general and apply over wide areas; the third is local in effect, depending on geological formations. Of still more local nature are exposure on slopes to different points of the compass, topographical configuration and the direction of prevalent winds or of currents of water in rivers or in the oceans. Temperature is doubtless the most potent of these influences. Inasmuch as it is governed mainly by latitude and altitude, we are driven to these as the prime factors influencing geographical distribution.

Taking first the general aspect of the problem, we can see at once, without much investigation, a possible division of our North American Flora into a northern and a southern. The northern occupies, almost to the exclusion of the southern, nearly all of British America, extending into the mountains of New York and New England, and south along the Blue Ridge and Allegheny mountain systems to Georgia. An incomplete representation of it occurs on the higher parts of the central states, and it is very strongly represented on the Rocky Mountains, the Sierra Nevada, the Coast Range and parallel ranges of the West, extending into Mexico. Some of its elements occur on the Andes of South America, and a most interesting similarity can be traced between the flora of the Straits of Magellan and that of a corresponding latitude in Quebec and Labrador. Much of it is also circumboreal, occurring in northern and elevated portions of Europe and Asia.

The southern flora occupies all the lower lands of tropical America, the West Indies, the Gulf States, Mexico, New Mexico, Arizona and southern California. It extends along the Atlantic Coast northward to eastern New England (a few species even farther north), up the Cumberland Valley to Pennsylvania, some elements of it even into New York, up the great interior region to Illinois, Indiana and Iowa or indeed to the British boundary; it is found throughout the extent of the Great Basin and its parallel valleys to the west, and along the Pacific Coast in California. This group of plants is, perhaps, more distinctively and purely American than the former, but has much interesting affinity with the floras of the warmer parts of the Old World.

The distribution of the natural orders represented in our flora, based mainly on the number of species represented, may be tabulated as follows: N. indicating of the northern group, S. of the southern.

Ranunculaceæ	N	Myrsinæ	S
Dilleniaceæ	S	Sapotaceæ	S
Calycanthaceæ	S	Ebenaceæ	S
Magnoliaceæ	S	Styracaceæ	S

Anonaceæ	S	Oleaceæ	S
Menispermaceæ	S	Apocynaceæ	S
Nymphæaceæ	S	Asclepiadæ	S
Sarraceniaceæ	S	Loganiaceæ	S
Berberidæ	N	Gentianæ	N
Papaveraceæ	N	Polemoniaceæ	N
Cruciferæ	N	Hydrophyllaceæ	S
Capparidæ	S	Boragineæ	S
Resedaceæ	S	Convolvulaceæ	S
Violaceæ	N	Solanaceæ	S
Cistinæ	S	Scrophularineæ	S
Canellaceæ	S	Orobanchaceæ	N
Bixinæ	S	Bignoniaceæ	S
Frankeniiæ	S	Pedalineæ	S
Polygalæ	S	Acanthaceæ	S
Caryophylleæ	N	Labiatae	S
Portulaceaæ	N	Plantagineæ	S
Tamariscinæ	S	Nyctagineæ	S
Elatinæ	S	Paronychiæ	N
Hypericinæ	S	Amarantaceæ	S
Ternstroemiaceaæ	S	Chenopodiaceæ	S
Malvaceaæ	S	Phytolaccaceæ	S
Sterculiaceaæ	S	Batidæ	S
Tiliaceaæ	S	Polygonaceæ	S
Linæ	S	Podostomaceaæ	S
Malpigiaceaæ	S	Rafflesiaceaæ	S
Zygophylleæ	S	Aristolochiaceaæ	S
Geraniaceaæ	N	Piperaceaæ	S
Rutaceaæ	S	Laurineæ	S
Simarubeæ	S	Thymeleaceaæ	S
Burseraceaæ	S	Eleagnaceaæ	N
Meliaceaæ	S	Loranthaceaæ	S
Olacinaæ	S	Euphorbiaceaæ	S
Cyrillæ	S	Urticinæ	S
Celastrinæ	S	Platanaceaæ	S
Rhamnæ	S	Leitneriaceaæ	S
Ampelidæ	S	Juglandæ	S
Sapindaceaæ	S	Myricaceaæ	S
Anacardiaceaæ	S	Casuarinæ	S
Leguminosæ	S	Cupuliferæ	N
Rosaceaæ	N	Salicinæ	N
Saxifrageæ	N	Ceratophylleaæ	S
Crassulaceaæ	N	Empetraceaæ	S
Hamamelidæ	S	Gnetaceaæ	S
Haloragæ	S	Coniferæ	N
Rhizophoreæ	S	Cycadaceaæ	S
Combretaceaæ	S	Hydrocharidæ	S

<i>Myrtaceæ</i>	S	<i>Burmanniaceæ</i>	S
<i>Melastomaceæ</i>	S	<i>Orchidææ</i>	S
<i>Lythrarieæ</i>	S	<i>Scitamineæ</i>	S
<i>Onagraceæ</i>	S	<i>Bromeliaceæ</i>	S
<i>Loasaceæ</i>	S	<i>Hæmodoraceæ</i>	S
<i>Turneraceæ</i>	S	<i>Iridææ</i>	S
<i>Passiflorææ</i>	S	<i>Amaryllideæ</i>	S
<i>Cucurbitaceæ</i>	S	<i>Dioscoreaceæ</i>	S
<i>Cacteæ</i>	S	<i>Roxburghiaceæ</i>	S
<i>Ficoidæ</i>	S	<i>Liliaceæ</i>	S
<i>Cactaceæ</i>	S	<i>Pouteriaceæ</i>	S
<i>Umbelliferæ</i>	N	<i>Xyridææ</i>	S
<i>Araliaceæ</i>	N	<i>Mayacaceæ</i>	S
<i>Cornaceæ</i>	S	<i>Commelinaceæ</i>	S
<i>Caprifoliaceæ</i>	N	<i>Juncaceæ</i>	S
<i>Rubiaceæ</i>	S	<i>Palmeæ</i>	S
<i>Valerianææ</i>	N	<i>Typhaceæ</i>	S
<i>Compositæ</i>	S	<i>Aroidææ</i>	S
<i>Goodeniaceæ</i>	S	<i>Lemnaceæ</i>	S
<i>Campanulaceæ</i>	S	<i>Allismaceæ</i>	S.
<i>Ericaceæ</i>	N	<i>Naiadaceæ</i>	S
<i>Lennoaceæ</i>	S	<i>Eriocaulææ</i>	S
<i>Diapensiaceæ</i>	N	<i>Cyperaceæ</i>	S
<i>Plumbaginææ</i>	S	<i>Gramineæ</i>	S
<i>Primulaceæ</i>	N		

We may now advantageously consider how the facts at hand may be used in speculating on the probable origin of the present distribution of our flora. In this we must first of all bear in mind that the present is only the last of a great number of distributions which have preceded it in past geologic time as the conditions of climate have been continually changing. Again we must reach beyond our own science for clews and suggestions to aid in the elucidation of the problem. We must interrogate the geologists for their knowledge concerning past topographical and climatic conditions of our continent. We must obtain from the palæontologists the facts at their command concerning past floras, more especially those of the Quaternary and Tertiary epochs. We must ascertain what conclusions the zoölogists have arrived at, for with them we expect to find an analogous problem. The evolutionists must be laid under tribute for the information they may yield.

It has not been my good fortune to be able to devote the great amount of time to this question that the collation of all these data would require. I have only been able to secure some of the more important of them—rather such as I regard the more important. My friend, Dr. C. Hart Merriam, who has long been pursuing the inquiry from the standpoint of the zoölogist would be able to discuss the details of it far more intelligently than it is possible at the present for me to do.

The present system of distribution, so far as the northern hemisphere is concerned, dates only from the time of the retreat of the glaciers to ap-

proximately their present position subsequent to the last Ice Age, of which the epoch is variously estimated on astronomical data at from 60,000 to 240,000 years ago. At that epoch the glaciers extended south to New York Harbor and southern Indiana on the eastern side of the continent and we must suppose that all organic existence was obliterated from this latitude of about 39° or 40° to the polar regions. The Rocky Mountain area and the parallel mountain systems of the west coast were occupied by ice-sheets to points nearly if not quite as far south, indicating that little or no life could have there existed at this time. It is clear then, that we must look to the south for the location during this period of intense cold of the immediate ancestors of our present flora.

It may be assumed with a fair chance of probability that regions equally distant to the south of the most southern extent of the glaciers at different periods, have had approximately similar climates. This would indicate that the Gulf States and northern Mexico experienced a climate in the last glacial epoch much like that now obtaining in eastern Canada and British Columbia—at least in so far as temperature is concerned. Ancestral species of plants and animals, similar or identical, may then have inhabited these southern areas, and the most southern peaks of the Appalachian mountain system and the highlands of Mexico were probably points of distribution for the present boreal flora, which has since become so widely and uniformly distributed over the entire circumboreal part of the northern hemisphere. A similar set of conditions must have existed on the eastern continent.

The question now arises, going back still farther in time, Where were the representatives of the present boreal flora prior to the glacial epoch? It has been supposed that they were in northern regions and were driven south by the advancing glaciers. This hypothesis may be correct, but as yet palaeobotany affords no proof of it. The climate of the Tertiary is well understood to have been warm or tropical in the northern parts of the continent, and plants of tropical types occurred as far north as Greenland. It seems almost impossible that any of these could have been the direct progenitors of the plants existing only in cold climates. And is it not indeed more probable, that this subtropical northern Tertiary flora, was obliterated rather than forced to the south? I will not attempt at the present time to suggest answers to these interesting problems, but commend them to the attention of the Section. Mr. William Carruthers has considered and discussed the subject in an exceedingly valuable communication recently made to the Linnean Society of London to which I would refer for a detailed statement of the difficulties involved in its solution, for which, I believe facts enough are not yet at hand.

Passing now to a brief discussion of the southern flora of our country, we find that one of its most remarkable features is its similarity to that of regions of like latitude in the Old World, and this similarity is even more pronounced when we compare the floras of tropical America, Asia, Africa and Australia. We are all well acquainted with the uniformity of composition of the circumboreal flora. The other has not been so forcibly brought to our attention. And yet it exists and is very well marked.

At the last meeting of the Association I called attention to the many elements in common among the tropical American and Old World Cyperaceæ, a large proportion of identical species and many more which could fairly be called representative being enumerated. This interesting alliance may be traced throughout nearly the entire vegetable system as must become apparent to every student of tropical vegetation. Hardly sufficient numerical estimate has been made of the identical species to be very satisfactory. There is a pamphlet entitled "Vergleichung der Floren des Westindischen und Ostindischen Archipels" published as an "inaugural dissertation" by Dr. Alfred Bernard at Halle, in 1877, which is valuable and suggestive. Dr. Bernard then found that 316 species were identical and the regions contained 485 genera in common. I think it certain that these figures are low, and if the number which might be considered as representative were tabulated, the list would be even larger.

Geologists do not give us much encouragement in support of a theory which supposes that the tropical regions of the Old and New Worlds have formerly been connected, affording a land area through which plant and animal migration would be unrestricted, and it is very difficult to account for the floral similarities of tropical regions by any system of distribution.

Again, a very difficult matter to explain by plant migration is the occurrence of a considerable number of purely boreal types at the Straits of Magellan and on the higher Andes, numerous species found in northern North America growing in these regions of similar climatic conditions. The similar climates of eastern Asia and eastern North America support, as has long ago been pointed out by Dr. Gray, many identical species.

And, indeed, taking a broader view of the question, why is it that all regions of like climates possess similar and often in large part identical species? Can this all be satisfactorily explained by migration alone? It appears to me, from my present knowledge of the subject that this explanation is not sufficient, but rather that the same environment has produced similar results from similar, or perhaps even dissimilar beginnings, and that we must turn to this hypothesis of parallel development long ago advocated in an extreme sense by Grisebach, to explain some, if not many of the obscure cases which we know very well to exist.

DEVELOPMENT OF THE SPOROCARP OF *GRIFFITHSIA BORNETIANA*. By V.
M. SPALDING, Ann Arbor, Michigan.

[ABSTRACT.]

THE following points of interest were brought out in the study of the development of this species:

1. Great variability in number and position of peripheral cells, including the one from which the trichophore is produced.
2. The early formation of spore-producing cells, rendering it doubtful how far the production of spores is the result of fertilization.
3. Differences between this and the closely related species *Griphithsia corallina* in the development of the sporocarp.

ON THE SEED-COATS OF THE GENUS EUPHORBIA. By Prof. L. H. PAMMEL,
Ames, Iowa.

[ABSTRACT.]

THE genus *Euphorbia* has been elaborated by many systematic botanists. Some species are difficult to discriminate. The seeds as is well known offer excellent characters to distinguish species. Thus in *Euphorbia polygontolia* and *E. Geyeri* the seeds are smooth, even and ash colored, while in *E. glyptosperma*, *E. maculata* and other members of this section they are usually ash colored and minutely roughened. The question naturally arises does the minute structure of the seeds offer good characters? In other orders the question has been answered in the negative. The seeds of many plants have been studied with a view to get some characters in the seed-coats which will assist in the determination of difficult and closely related species. H. Godfrin¹ who has examined the seed-coats of thirty-four orders finds that while the structure of the seed-coats is useful in some directions it often is of no taxonomic value. Ewald Bachmann, in his excellent paper on the development and structure of the seed-coats of *Scrophulariaceæ*, expresses the opinion that microscopic characters of the seed-coats are of little value from a systematic point.²

Though I have examined a large number of seeds of the order *Leguminosæ* I have found only minor deviations. It is to be expected that the Malpighian³ cells differ in size in different genera. These peculiar cells with a well marked light line are characteristic for the entire order. Closely related species and even genera only show minor deviations in structure.

The seed-coats of *Euphorbiaceæ* have been studied but little. Gris⁴ who first studied the development of the seeds in *Euphorbiaceæ* has shown that the seeds are provided with two seed-coats. Poisson⁵ who also studied the seed-coats of *Euphorbiaceæ* finds that different species and genera differ in regard to the number of layers of cells in the outer and inner seed-coat. In my own studies of the genus I find that there is considerable variation. In *E. dentata* the outer integument is made up of three layers of cells while the inner is made up of two. In *E. commutata* the outer seed-coat is composed of four layers while the inner has from three to four. The number of layers of cells to a given integument is not always an easy matter to decide, as the seeds are so compressed and brittle that it is difficult to obtain satisfactory sections. In all the species I have examined the outer integument has a brown palisade-like layer; these cells are pro-

¹Étude histologique sur les teguments seminaux des angiosperms. Nancy, 1880, pp. 112, 5 plates.

²Die Entwicklungsgeschichte und der Bau der Samenschalen der Schrophularineen. Halle, 1880, pp. 179, 4 plates. See p. 170.

³O. Mattirola. La linea lucida nelle cellule Malpighian degli integumenti seminali (Mem. della R. Acc. delle Sc. di Torino Ser. II, Vol. XXXVII). See Solla Just Bot. Jahrb., 1885, p. 825. Mattirola calls attention to the fact that Targioni Tozzetti in 1853 described the palisade-like cells of the Leguminosæ and called them Malpighian cells.

⁴Ann. Sc. nat. Ser. 4. Vol. xv, No.1.

⁵Bull. Soc. bot. de France, 1878.

vided with pores. The position of this layer varies in different species. In roughened seeds like *E. dentata* the outer layer of the outer integument is made up of irregular papillate-like cells. The cell-cavity is large, while the outer cell-wall is much brighter and clearer. This cell-wall has a laminated structure. In *E. obtusata* these cells are regular. In *E. commutata* they are absent. In *E. dentata* the cells of the layer next to the endosperm are elongated in a longitudinal direction. The cells are marked by thickened bars which resemble those found in the leaves of certain orchids and the anthers of pines, etc. Turning our attention again to the outer cells of the outer integument we find something which is of interest, histologically, as it adds more plants to the list of those which abound in mucilage. It has been known for a long time that the seed-coats of some seeds, fruits, and tissues of plants abound in mucilage. This mucilaginous substance occurs in the seeds of *Plantago*, *Collomia*, *Gilia*, *Polemonium*, *Linum*, *Brassica*, *Lepidium*, *Pyrus (Cydonia) vulgaris*, *Ruellia*, *Acanthodium*, etc.; in the tissues of *Althaea*, etc. In the seed coats of *Linum* the mucilaginous property lies in the thickened outer cell-walls. On addition of water to the seeds of *Collomia* the seed coats expand producing spiracles. This peculiarity was first noticed by Lindley.¹ The seeds of *Polemonium*, *Ruellia*, etc., behave in the same way. This seems not to have been observed for *Euphorbia*, although Harz² doubtfully refers to mucilage in the third layer of cells of the outer integument of *Euphorbia Lathyris*. In *E. polygonifolia* where I first noticed it, the ash colored part readily separates from the remainder of the seed. On placing this ashy part in water the outer cells of the outer seed coat expand producing copious spiracles. As this structure is so much like that of *Collomia* I will quote what Dr. Gray says of it. "The mucilage so copiously developed on the surface of the seed when immersed in water, and which gave the name of the genus, consists of numerous diaphanous tubes which lengthen wonderfully when wetted."³

THE DEVELOPMENT AND FUNCTION OF THE SO-CALLED CYPRESS—"KNEES,"
TOGETHER WITH A SHORT CONSIDERATION OF THE NATURAL HABITAT OF
THE TREE. By Dr. W. P. WILSON, University of Pennsylvania, Phila-
delphia, Pa.

[ABSTRACT.]

FROM a careful consideration of both developing seedlings and adult forms of the Bald Cypress (*Taxodium distichum*), grown in wet and in dry locations, the following conclusions have been reached: the "knees" are in all cases true roots, variously modified. They have several widely vary-

¹Edwards' Botanical Register, Vol. XIV, 1828, p. 1166.

²Landwirthschaftliche Samenkunde, Vol. II, p. 833. Fig. 47, vi, d.

³Botanical Contributions, VII, Jan., 1870.

ing methods of development, resulting however in the end in similar forms. These methods may be very briefly described as follows: Any very small growing root may extend upward to the surface at varying angles, after which it turns downward and grows deep into the soil at nearly the same angle as that observed in its ascent. Active growth begins at once on the upper or exposed portion of the root, which continuing produces a knee extending vertically up into the air. Again any root tip may grow vertically up through the soil or water until exposed to the air. The portion in the air begins at once to thicken up, sends down new lateral roots as supports, and thus forms a "knee." In a third method the "knees" are formed from protuberances developed on the upper side of already well-grown horizontal roots.

Sometimes closely approximating knees become welded together in one common mass, which later grows and develops as though it were but one "knee." This results often in a very complex structure.

The tree never produces "knees" in dry soil, and never fails to do so when flooded with water.

By cultivating seedlings with varying degrees of moisture the "knees" may be produced or withheld at will. Fully grown trees, with masses of "knees" surrounding them lose them all upon sufficiently draining the soil. The tree grows just as vigorously without them. Such "knees" quickly decay away after such drainage.

On the whole the cypress seems to grow with more vigor in dry soil than in wet. There are numerous indications to make it seem probable that it is naturally an upland form and that the "knees" are acquired organs of respiration to enable it to live in the swamps.

FOREST TREES OF INDIANA. By Prof. STANLEY COULTER, Lafayette, Ind.

[ABSTRACT.]

AN enumeration of the forest trees of Indiana with notes as to distribution as effected by character of soil, latitude and elevation.

The list enumerates one hundred and six species of forest trees distributed among twenty-four orders and fifty-one genera. The largest representation is found in the Cupuliferae with seven genera and twenty-four species. The list is also characterized by the paucity of Coniferae, which shows only five genera and seven species. Of these the most remarkable is *Taxodium distichum* Richards, found in considerable quantity in the southwestern counties, where it reaches its northern limit.

THE TRIMORPHISM OF UROMYCES TRIFOLII (ALB. AND SCHW.). WINT. By J. K. HOWELL, Painted Post, N. Y. Presented by W. R. DUDLEY.

[ABSTRACT.]

THE genetic relationship between the *Aecidium* growing on clovers and the parasitic *Uromyces trifolii*, the "Clover Rust," has heretofore rested on

a possibly correct surmise rather than on actual proof. In order to ascertain definitely whether such a connection really exists, a study of the subject was pursued during nine months in the Cryptogamic Laboratory of Cornell University.

Almost daily observations were made of plants of *Trifolium repens* and *T. pratense* attacked by aecidial, uredo and teleutosporic forms. It was found that an undoubted alternation of forms existed, the aecidium being frequently followed by the other forms and they in turn by the aecidium. Fresh, mature uredo spores germinated readily at all times during the year. Their temperature limits were between 7° and 25° Cent., germination taking place most rapidly (in less than two hours) between 11° and 16° Cent. A considerable number of artificial infections, made with germinating uredo spores on leaves of small clover plants, invariably resulted in the production of uredo sori, showing that the uredo spores merely reproduce themselves. Of teleutospores, about fifty cultures were made during the year, both of fresh teleutospores from the living plants, and of those which had rested during the winter. Only one of the former and seven of the latter germinated, therefore no infections were attempted. The aecidiospores germinated at all times during the winter and spring; spores subjected to a temperature of 16° Cent. germinating in from one and one-half to two hours.

A number of plants of *T. repens* and *T. pratense* were infected with the germinating aecidiospores and on the infected leaves uredo sori invariably appeared, thus proving beyond doubt that the assumed relationship between the aecidium and the other forms actually exists and that the aecidium is merely a stage of *Uromyces Trifolii*.

Further investigations on the teleutospores will be carried on during the coming year.

NOTES ON A MONOGRAPH OF THE GENUS *LECHEA*. By Dr. N. L. BRITTON,
Columbia College, New York, N. Y.

[ABSTRACT.]

REMARKS on the history of the genus *Lechea* with especial reference to its treatment by American authors, its structural characteristics, number and distribution of its species with notes on their alliances. Illustrated by specimens.

PRELIMINARY NOTE ON THE GENUS *RHYNCHOSPORA* IN NORTH AMERICA. By
Dr. N. L. BRITTON, Columbia College, New York, N. Y.

[ABSTRACT.]

AN enumeration of the species of the genus *Rhynchospora* now known to inhabit North America with an account of their distribution. Illustrated by specimens.

ON RUSBYA, A NEW GENUS OF VACCINIACEÆ FROM BOLIVIA. By DR. N. L. BRITTON, Columbia College, New York, N. Y.

[ABSTRACT.]

RUSBYA is an interesting new genus of parasitic Vacciniaceæ, having stipules, a feature hitherto unknown in the order.

THE CONTINUITY OF PROTOPLASM THROUGH THE CELL WALLS OF PLANTS.
By Prof. W. J. BEAL and J. W. TOUMEY, Agricultural College, Mich.

[ABSTRACT.]

THE examination of species of seventy-five genera of woody plants to find the best for demonstrating the continuity of protoplasm in the cortex.

Methods employed not new; the results very satisfactory in *Alnus glutinosa*, and fair in *Syringa vulgaris*, *Viburnum opulus*, and *Amelanchier*. Usually shown in every species more or less distinctly, by using first-rate objectives of high power.

A few species of seeds examined, especially those with a hard endosperm.

NOTES UPON THE CRYSTALS IN CERTAIN SPECIES OF THE ARUM FAMILY.
By Prof. WILLIAM R. LAZENBY, Columbus, Ohio.

[ABSTRACT.]

THE liquid contents of the cells of different plants contain numerous inorganic substances in solution. In addition to these, crystals of mineral matter having various shapes and sizes are often found in the interior of cells. The most common of these are calcium oxalate and calcium carbonate, but calcium phosphate, calcium sulphate and silica are sometimes found. Like the milky juice, aromatic compounds, and various decomposition products, they undoubtedly serve as a means of protection. The raphides, or needle-shaped crystals, appear to have the power of producing the intense acridity characteristic of certain species. That this is produced by the crystals is shown by the following evidence:

1. The acridity is in proportion to the number of these crystals.
2. The sensation is not strictly acrid but prickling and does not begin until some little time has elapsed after tasting.
3. The sensation is not caused by any volatile principle.
4. Filtration separates the acridity from the clear juice.
5. The acridity is lost by dialysis.

OBSERVATIONS ON THE METHOD OF GROWTH OF THE PROTHALLIA OF THE FILICINÆ, WITH REFERENCE TO THEIR RELATIONSHIPS. By DOUGLAS H. CAMPBELL, Detroit, Mich.

[ABSTRACT.]

REVIEW of previous observations.

Apical growth in the Filicinæ.

Comparison with Bryophytes.

Notes on the archegonium.

Conclusion.

CONTRIBUTIONS TO THE LIFE-HISTORY OF ISOETES. By DOUGLAS H. CAMPBELL, Detroit, Mich.

[ABSTRACT.]

REVIEW of earlier investigations.

Methods employed.

Development of female prothallium and archegonium.

Notes on male prothallium.

Development of embryo.

Conclusion.

PRELIMINARY NOTES ON A NEW AND DESTRUCTIVE OAT DISEASE. By B. T. GALLOWAY, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

GIVES results of an investigation into the nature of a disease which ravaged the oat crop in all the states east of the Mississippi this year. The disease is due to a microorganism. The organism has been grown in various culture media and the disease produced in oats by inoculations from this material. Culture methods, staining, behavior of germ on various media, etc., explained.

OBSERVATIONS ON THE LIFE-HISTORY OF UNCIJNULA SPIRALIS. By B. T. GALLOWAY, Dept. of Agriculture, Washington, D. C.

[ABSTRACT.]

RESULTS of investigations extending over two years. Life-history of the fungus given in full. Methods of establishing the relationships of the various forms explained.

THE SPECIFIC GERM OF THE CARNATION DISEASE. By Prof. J. C. ARTHUR
and H. L. BOLLEY, La Fayette, Ind.

[ABSTRACT.]

THE paper states the results of a very complete study of the bacterium, which has been isolated and proven to cause a disease peculiar to the carnation and other pinks. A general description of this disease was presented to the Society at its Toronto meeting. Living cultures of the germ, and drawings illustrating its development and characteristic growth accompanied the present paper.

POTATO SCAB, A BACTERIAL DISEASE. By H. L. BOLLEY, La Fayette, Ind.

[ABSTRACT.]

THE first third of this paper is given to a somewhat careful statement of the theories previously held regarding the primary cause of potato scab, including quotations from and citations of much of the principal literature of the subject, after which the original investigations of the author are detailed under the following general headings:

History of first investigations and observations.

Inoculation or infection tests.

"Scabby vs. smooth seed."

The effect of disease-bearing seed tubers upon the new product.

Biology of the bacterium of potato scab.

(a) Culture methods.

(b) Characteristics of growth upon artificial, nutrient, culture media, solid, liquid, neutral, acid, alkaline, etc.

(c) Effect of different temperatures upon the bacterium.

(d) Effect of different gases upon its development.

(e) General description of the bacterium of potato scab.

Relation of the bacterium to the host, effect upon the tissues, manner in which the disease is engendered, etc.

General discussion of the results of the original investigations in connection with facts and phenomena heretofore recorded and observed by other investigators.

The paper indicates that the theories heretofore held in regard to the direct cause of the disease have either been disproved or are insufficiently substantiated to be tenable, and bases the assertion of a bacterial origin upon the following work done by the author:

(1) The observation that a specific bacterium is a constant factor in the history of a true potato scab.

(2) The raising of diseased products from diseased seed tubers, and the treatment of similar scabby seed and the raising therefrom under like conditions a crop void of disease.

(3) The raising of healthy tubers by isolation in the same hill in which all the others became diseased.

(4) And finally the production of the disease at will upon healthy tubers by means of artificial infection.

THE HARVEST SPIDERS OF NORTH AMERICA. By CLARENCE M. WEED,
Columbus, Ohio.

[ABSTRACT.]

THE author briefly reviews the history of our knowledge of North American Phalangiidæ, and gives the results of a recent study of our Phalangid fauna as represented by collections made in widely separated states. A new genus, Forbesium, is characterized, and the following list of North American species is given :

Family PHALANGIIDÆ.

Sub-family SCHLEROSONMATINÆ.

Genus *Astrobumus* Thorell.

1. *A. nigrum* (Say) Weed.
2. *A. (?) bicolor* (Wood) Weed.
3. *A. (?) favosum* (Wood) Weed.
4. *A. (?) grande* (Say) Weed.

Sub-family PHALANGIINÆ.

Genus *Liobunum* Koch.

5. *L. dorsatum* (Say) Weed.
6. *L. elegans* Weed.
7. *L. longipes* Weed.
8. *L. maculosum* (Wood) Weed.
9. *L. nigropalpi* (Wood) Weed.
10. *L. politum* Weed.
11. *L. simile* Weed (MS.)
12. *L. ventricosum* (Wood) Weed.
13. *L. verrucosum* (Wood) Weed.
14. *L. vittatum* (Say) Weed.
15. *L. exilipes* (Wood) Weed.
16. *L. (?) calcar* (Wood) Weed.

Genus *Forbesium* Weed.

17. *F. hyemale* Weed.
18. *F. formosum* (Wood) Weed.

Genus *Phalangium* (Linn.)

19. *P. cinereum* Wood.
20. *P. longipalpis* Weed.

Genus *Oligolophus* Koch.

21. *O. ohioensis* Weed.
 22. *O. pictus* (Wood) Weed.
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FOOD OF BEES. By Prof. A. J. COOK, Agricultural College, Mich.

[ABSTRACT.]

THE elements of the food of bees and the source of each. The importance of each and the probable function. Albuminous food not essential in winter in our climate. Experimental proof of this. Bees fed for winter, syrup, pure honey, and wintered on wooden combs. Explanation of this latter fact.

ON THE STRUCTURE OF CERTAIN PALEOZOIC FISHES. By Prof. E. D. COPE, Philadelphia, Pa.

[ABSTRACT.]

THE characters of the skull of the genus *Macropetalichthys* not having been hitherto correctly described, the author endeavored to do so as far as his material would permit, and showed that the genus belongs to the Placodermata, and not to the Chondrostei as hitherto supposed.

The limbs of the *Megalichthys nitidus* were described. They were shown to bear some resemblance to the pinnate unibasal type or Archipterygium but none to the tribasal type of *Polyterus*, and to resemble most those of the *Antiarcha* (*Bothriolepis*, etc.), but with a fringe of internal rays on the inner side and at the extremity.

A species of *Platysomus* from the Permian bed of the Indian Territory was described, and attention called to a peculiar structure of the inferior portion of the scapular arch. The inferior extremity of each clavicle turns backwards, and the two embrace a pair of median elements which may be interclavicles or coracoids. The four elements together form a short horizontal tube.

A species of *Dendrodus* from the Permocarboniferous of Nebraska was described.

ON THE PLATES OF *HOLONEMA RUGOSA*. By Prof. H. S. WILLIAMS, Ithaca, N. Y.

[ABSTRACT.]

FOUR plates of this remarkable fish have been discovered in the Oneonta formation near Oxford, N. Y. (Devonian).

Photographs of the plates in their natural position are for exhibition, and remarks will be made regarding the interpretation of the plates and their relations to other described fish.

The author interpreted the plates as dorsal, instead of plastron plates as the original plate discovered by Professor Claypole was interpreted by him and by Dr. Newberry in proposing the generic name *Holonema*. The plates were explained in the relations figured in the cut in the American Geologist, Vol. vi, p. 256, and the similarity to the arrangement of the dorsal plates of *Bothriolepis* was noted.

The evidence was that the plates came from the Oneonta sandstone below the typical Chemung marine fauna.

COMBINED AQUATIC AND AERIAL RESPIRATION IN AMPHIBIA AND THE FUNCTION OF THE EXTERNAL GILLS IN SALAMANDERS HATCHED ON LAND.
By Prof. SIMON H. GAGE, Ithaca, N. Y.

[ABSTRACT.]

THE observations and experiments described by the author seemed to show clearly that

(1) When the respiration of an animal is in part aerial and in part aquatic, the aerial part is principally to furnish oxygen and the aquatic part to eliminate carbon dioxide.

(2) The external gills of Amphibia (Salamanders) hatched on land are true respiratory organs, answering in general function to the allantois of birds and the placenta of mammals.

CHANGES IN THE CILIATED AREAS OF THE ALIMENTARY CANAL OF THE AMPHIBIA DURING DEVELOPMENT AND THE RELATION TO THE MODE OF RESPIRATION. By Prof. SIMON H. GAGE and SUSANNA PHELPS GAGE, Ph.B., Ithaca, N. Y.

[ABSTRACT.]

THE salient points brought out by this investigation are as follows:—

(1) Ciliated epithelium is, in the early stages of development, entirely absent from the entire alimentary canal in all Amphibia.

(2) Cilia appear upon the epithelium in the oesophagus, at least, in all forms of Amphibia, after the food yolk has mostly or completely disappeared.

(3) In the larval stages of aquatic, carnivorous species (Salamanders), ciliated epithelium is confined to the oesophagus, where it is probably useful in moving food toward the stomach.

(4) In the larvae of frogs and toads (vegetable feeders), the ciliated epithelium is found in the oesophagus, stomach, part of the intestine; and, in some stages, in the cloaca. With the change in the mode of respiration and the acquirement of the carnivorous habit, the ciliated epithelium undergoes a complete histolysis or retrograde metamorphosis and a new formation of it appears in the oesophagus only, and the stratified epithelium of the mouth is replaced by ciliated. It is stated by some authors that there are patches of ciliated epithelium in the stomach of the adult, but we have failed to discover it in American forms.

(5) In all forms of Amphibia and in all stages after the complete disappearance of the food yolk, ciliated epithelium is absent from the mouth when the respiration is mostly aquatic and water is frequently taken into the mouth; and that in forms with mostly aerial respiration, and water is rarely taken into the mouth, the mouth is lined with a ciliated epithelium.

(6) Whenever ciliated epithelium is present in any part of the alimentary canal, the ciliary current is always in a caudal direction, i. e., in the direction followed by the contents of the digestive tube.

(7) The absence of ciliated epithelium from the mouth in forms with preponderant aquatic respiration may be accounted for on the ground that the ciliary current, if present, would tend to cause a stream of water to pass almost constantly into the stomach.

NOTES ON THE AMPHIBIA OF ITHACA. By Prof. SIMON H. GAGE and H. W. NORRIS, Ithaca, N. Y.

[ABSTRACT.]

THE authors show:—

(1) That of the four great groups of Amphibia given by E. D. Cope in his monograph of the Batrachia of North America, representatives of three of the groups, viz., Proteida, Urodela and Salientia, are found in the Ithaca fauna. Of the thirty-one genera and 107 species in North America, Ithaca possesses eleven genera and eighteen species. That is, the higher groups have a better representation than the lowest.

(2) That *Diemyctylus viridescens*, the adult and mostly aquatic form, and *Diemyctylus minutus* the vermillion and terrestrial forms were found to be different stages of the same species. This was proved by keeping the red form until spring when it entered the water and assumed the viridescent color and aquatic habits of the *D. viridescens*, thus verifying

previous observations. By means of careful experiments it was also proved that the fertilization of the eggs of *Diemyctylus* is internal.

(3) Of all the species found in Ithaca the early stages of development of *Amblystoma punctatum* are most easily and satisfactorily followed as the time of ovulation continues for about three weeks; the eggs are large and easily removed from the albumen at all stages, and finally they develop slowly, requiring from two to three weeks to hatch.

(4) Of the two species of the genus *Hyla*, *H. Pickeringii* lays its eggs singly upon water plants, while *H. versicolor* lays its eggs in masses, but the masses are attached to water plants.

The development of both is rapid, requiring only from eight to ten days. Both transform in July and the early part of August, and the peculiarities of the species appear in the tadpoles while the tail is still as long as the body.

A SUPPORT FOR THE CHORDA TYMPANI NERVE IN THE FELIDÆ. By THOMAS B. SPRUCE, of Ithaca, N. Y. Presented by S. H. GAGE.

[ABSTRACT.]

THE author describes a bony process at the entrance of the chorda tympani nerve into the cavity of the tympanum. The nerve extends to the top of the support and then traverses the cavity, the support lifting the nerve free so that it does not come in contact with the drum of the ear, thus avoiding any disturbing effect upon the delicate vibrations of the membranous tympani which might result if the nerve rested directly upon it.

STRUCTURE OF THE STOMACH OF AMIA CALVA. By GRANT S. HOPKINS, of Ithaca, N. Y. Presented by S. H. GAGE.

[ABSTRACT.]

THE author shows:—

(1) That the stomach of *Amia* is a true digestive cavity by careful experiments.

(2) That the lining epithelium is ciliated nearly to the pylorus, and that the ciliated cells extend for a considerable distance into the mouths of the gastric tubules. In the deeper parts of the tubules they are replaced by the proper spheroidal glandular cells—no parietal cells were found. In the pyloric regions, especially beyond the ciliated portion, the tubules are lined throughout with columnar cells and many of them are branched.

(3) The ciliary current has a caudal direction, thus agreeing with the Amphibia.

ON THE LACK OF THE DISTANCE SENSE WITH THE PRAIRIE DOG (*Cynomys ludovicianus*).¹ By Prof. BURT G. WILDER, Ithaca, N. Y.

[ABSTRACT.]

SEVERAL individuals at Cornell University seemed to lack the sense of distance which is so conspicuous with some other rodents. This may be correlated with the nature of their habitat. Nevertheless, one adult female has survived falls of 6.6 meters, once upon wood and once upon stone, with no serious injury. The second fall is believed to have resulted from the unguarded erection of the body upon a window-sill at the striking of a clock. This erection and the accompanying bark seem to involve a nervous mechanism which is mainly reflex, nearly uncontrollable, and rapidly exhausted. This individual is now 7½ years old, 30 cm. long and weighs 755 grams. It recognizes familiar hands and voices, is practically omnivorous, drinks milk and killed and devoured a ruffed grouse. It disappeared (temporarily) after the second fall; the writer, who is much attached to it, wrote directions for its recovery, urging that some steps be removed if necessary; the following night he dreamed of superintending the demolition of McGraw Hall; neither to him nor to others did there appear, in the dream, anything incongruous in the destruction of a fifty thousand dollar stone building for the recovery of a prairie dog.

EXTERNAL TERMINATION OF THE URETHRA IN THE FEMALE OF GEOMYS BURSARIUS. By Prof. HERBERT OSBORN, Ames, Iowa.

[ABSTRACT.]

AN interesting point in the anatomy of the common pocket gopher, *Geomys bursarius*, and one which, so far as I can find, has not been recorded heretofore, is that the urethra in the female, instead of terminating in the vagina, extends to the skin and terminates by an independent external orifice situated a short distance ventral to the vulva.

This appears to be an exception to the rule in all mammals, and would place the Geomydæ, in this feature, farther from the Sauropsida than any other member of the mammalian class. It does not occur in any other group of rodents so far as I am aware, and while a very interesting modification of a very constant character can not probably be considered of any particular phylogenetic importance. The males, though not yet examined critically in fresh specimens, have so far as can be seen in the material at hand no corresponding modification in these parts.

The urethra as a whole is comparatively short, running in a direct line from the bladder to the external termination, which is indicated externally by only a slight eminence nearly conical in form and situated only three

¹For a fuller abstract of this paper see *Science*, Aug. 23, 1890, and *The Ithaca Journal*, Oct. 21, 1890.

or four millimeters from the vulva, nearly the same distance from the vulva that the vulva is from the anus, and the space separating the openings is covered with hairy skin.

The possibility of this being an abnormal development seems precluded by the fact that though but few individuals have been critically examined, the structure has been the same in all.

It will be of interest to learn the condition of these structures in the allied genus *Thomomys*.

MORPHOLOGY OF THE BLOOD CORPUSCLES. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

If one goes through the very extensive literature dealing with blood corpuscles, one finds the most divergent views defended, and can hardly reach clear ideas, for the conceptions do not agree among themselves either as to the structure or as to the development of the corpuscles. According to some the red corpuscles arise from the white, according to others the white corpuscles arise from the red, and according to still others both kinds arise from indifferent cells. In regard to one point only is the majority of investigators united, namely, in the silent assumption that all blood corpuscles are of one and the same kind, in spite of the absence of the nucleus in mammalian corpuscles. It is just this assumption that has caused endless confusion, and the morphology of the blood corpuscles can be cleared up only by starting with the recognition of the fundamental difference between nucleated and non-nucleated corpuscles. Farther, it must be recognized that no corpuscles, neither red nor white, arise from nuclei.

The origin of red corpuscles from nuclei has been maintained several times. This notion is based upon defective observations. It is very easy, in the chick for example, to convince one's self that the first blood corpuscles are cells; in the area vasculosa, at the time of the blood formation, the red blood-cells are readily seen, in part lying singly, in part in groups (blood islands) adherent to the vascular walls. The free cells are constituted chiefly by the nucleus, which is surrounded by a very thin layer of protoplasm, which is very easily overlooked, especially if the preparation is not suitably stained; this explains, I think, the statement made by Balfour (Works, Vol. 1) and others that the blood corpuscles consist only of nuclei. By following the development along further we find that the protoplasm enlarges for several days, and that during the same time there is a progressive diminution in size of the nucleus, which, however, is completed before the layer of protoplasm reaches its ultimate size. The nucleus is at first granular, and its nucleolus, or nucleoli, stand out clearly; as the nucleolus shrinks it becomes round and is colored darkly and almost uniformly by the usual nuclear stains. This species of blood corpuscle occurs in all vertebrates and represents the *genuine blood cells*. Accord-

ing to the above description we can distinguish three principal stages:—
1°, young cells with very little protoplasm; 2°, old cells with much protoplasm and granular nucleus; 3°, modified cells with shrunken nucleus which colors darkly and uniformly. I do not know whether the first form occurs in any living adult vertebrate, although the assumption seems justified that they are the primitive form. On the other hand the second stage is obviously characteristic of the Ichthyopsida in general, while the third form is typical for the Sauropsida. Therefore, the development of the blood-cells in Amniota offers a new confirmation of Louis Agassiz's law (Haeckel's biogenetisches Grundgesetz).

The blood-cells of mammals pass through the same metamorphoses as those of birds. For example, in rabbit embryos, the cells have reached the Ichthyopsidan stage on the eighth day; two days later the nucleus is already smaller, and by the thirteenth day has shrunk to its final dimensions.

The white blood corpuscles appear much later than the red cells, and their exact origin has still to be investigated, for it has not yet been determined where they first arise in the embryo; nevertheless we may venture to assert that they arise outside the vessels. The formation of leucocytes outside of the vessels is already known with certainty to occur in later stages as well as in the adult. The sharp distinction between the sites of formation of the red and white cells appears with especial clearness in the medulla of bone in birds, as we know from the admirable investigations of J. Denys (*La Cellule*, Tome IV). The white blood corpuscles, then, are cells, which are formed relatively late, and wander into the blood from outside.

The non-nucleate blood corpuscles of adult mammals are entirely new elements, which are peculiar to the class and arise neither from red nor yet from white blood-cells. Their actual development was first discovered, so far as I know, by E. A. Schäfer, who has given a detailed account of the process in the ninth edition of Quain's Anatomy, and has shown there a full appreciation of the significance of his discovery. Unfortunately, Schäfer's important investigations have received little attention. Kuborn has recently confirmed Schäfer's results in an article (*Anatom-Anzeiger*, 1890) on the formation of blood corpuscles in the liver. One can readily study the process in the mesentery and omentum of human and other embryos. The essential point of Schäfer's discovery is that the non-nucleate corpuscles have an *intra-cellular* origin, and arise by differentiation of the protoplasm of vasoformative cells; several corpuscles arise in each cell without participation of the nucleus; they are, therefore, specialized masses of protoplasm, and may perhaps best be compared to the plastids of botanists. I venture to propose the name of blood-plastids for these structures, since the term corpuscle (*globule*, *Körperchen*) has no definite morphological meaning.

Sonsino (*Arch. Ital. Biol.* XI) affirms that the red blood-cells transform themselves into plastids; I have, however, never been able to find the intermediate forms in my own numerous preparations. I deem it probable that he has seen merely the degenerating stages of the red cells.

The above review shows that the vertebrate blood corpuscles are of three kinds: 1°, Red cells; 2°, White cells; 3°, Plastids. The red and white cells occur in all (?) vertebrates; the plastids are confined to the mammals. The red cells present three chief modifications; whether the primitive form occurs in any living adult vertebrate I do not know; the second form is persistent in the Ichthyopsida, the third form in the Sauropsida. According to this we must distinguish:—

- A. ONE-CELLED BLOOD, *i. e.*, first stage by all vertebrates; the blood contains only red cells with little protoplasm.
- B. TWO-CELLED BLOOD, having red and white cells. The red cells have: either a large, coarsely granular nucleus (Ichthyopsida) or a smaller, darkly staining nucleus (Sauropsida, mammalian embryos).
- C. PLASTID BLOOD, without red cells, but with white cells and red plastids; occurs only in adult mammals.

Mammalian blood in its development passes through these stages, as well as through the two phases of stage B, all in their natural sequence; the ontogenetic order follows the phylogenetic.

I pass by the numerous authors whose views conflict with mine, partly because the present is not a suitable occasion for a detailed discussion, partly because those authors, who have asserted the origin of one kind of blood corpuscle by metamorphosis from another, have failed to find just the intermediate forms; it seems to me, therefore, that most, at least, of the opposing views collapse of themselves.

DIFFERENTIATION OF THE PRIMITIVE SEGMENTS IN VERTEBRATES. By Dr. CHARLES SEDGWICK MINOT, Boston, Mass.

[ABSTRACT.]

The primitive segments are formed by mesothelium; the inferior wall is thickened in the higher vertebrates so much as to fill the cavity of the segments. The lower wall divides into connective tissue cells and muscle cells. The upper wall adds to the muscle cells and later breaks up entirely into connective tissue. The author's observations were made on the chick and rabbit and confirm the results obtained by others for the lower vertebrates.

ON THE FATE OF THE HUMAN DECIDUA PREFLEXA. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

The decidua reflexa is a distinct membrane up to the end, it is said, of the fifth month of gestation, and after that period it can no longer be found. Exactly at what time it disappears is not established by observation, though the fact of the disappearance has long been known, nor have we had hitherto any definite knowledge as to how it disappears although its

gradual attenuation and increasing transparency during the first four or five months have been familiar to us since the publication of Coste's magnificent atlas. The view most generally accepted has been that it fused with the decidua vera and that accordingly the layer of decidua nearest the chorion during the latter half of pregnancy represents the decidua reflexa.

I have had opportunity to study four well preserved normal pregnant uteri of two, three, five to six, and seven months gestation respectively. These show that at two months the decidua reflexa is undergoing hyaline degeneration, that at three months the degeneration is considerably more advanced, and that by the sixth and seventh month the reflexa can no longer be found. These observations justify the theory that the reflexa degenerates and is completely resorbed.

I will review briefly the actual observations:

First the reflexa at two months. It starts from the edge of the placental area with considerable thickness, which is rapidly lost, most of the reflexa being a thin membrane, and the thinnest point being opposite the placenta. The examination of sections shows that the entire reflexa is undergoing degeneration, which is found to be the more advanced the more remote the part examined is from the placenta. The chorion laeve lies very near the reflexa, being separated only by chorionic villi, which are very much altered by degeneration, their ectoderm having become a hyaline tissue which stains darkly, and their mesoderm showing clearly the partial loss of its cellular organization. In the region half way between the base and the apex of the reflexa dome the tissue of the decidual membrane shows only vague traces of its original structure; only here and there can a distinct cell with its nucleus be made out, for most of the cells have broken down and fused into irregular masses without recognizable organization. Ramifying through the fused detritus there are two layers of so-called "fibrine," or, in other words, of a hyaline substance, which like the "canalized fibrine" of the chorion stains very deeply with the ordinary histological dyes, carmine and logwood. The fibrine is much more developed upon the inner or chorionic than upon the outer side of the reflexa. It forms on the inner side a dense network, which on the one hand fuses with the degenerated ectoderm of the chorionic villi wherever the villi are in contact with the decidua; and on the other hand ramifies more than half way through the decidua, the ramifications being easily followed owing to the hyaline character and deep staining of the "fibrine." Upon the outside the fibrine forms a thinner layer and shows its network structure in many sections much less clearly.

In the uterus three months pregnant I find essentially the same conditions except that the degeneration is farther advanced, since the traces of cellular structure in the reflexa are still more vague and the fibrine is more developed. The membrane is much thinner than at two months; the thickness is about two-thirds of what it was. In the fresh specimen the membrane appeared much more transparent than before. In all the parts examined I found leucocytes present, and in the region of the reflexa near the placenta they are very numerous and conspicuous; it is natural to con-

clude that they are concerned in the resorption of the degenerated tissue. In a section not far from the base of the reflexa the three layers are distinct as at two months, there being a thicker inner and a thinner outer fibrine layer, while between them is a stratum in which remains of cells are seen: occasionally is an appearance which suggests a surviving decidual cell, and nearer the placenta the phantoms of cells become distinctly cells and true decidual cells can be made out. The inner fibrine layer is much denser and its meshes smaller than in the two months specimen, the trabeculae of fibrine having become thicker during the month elapsed.

The relations of the amnion and chorion to one another in a uterus of seven months I have already described and illustrated in detail in my article "*Uterus and Embryo*" (*Journal of Morphology*, Vol. II, 422-425, cuts 33-34). I will recall only that the chorion lies directly against the decidua, while between the chorionic mesoderm and the decidual tissue extends a layer of epithelioid cells, which I interpreted as the modified ectoderm of the chorion, a view which I still hold. Of a membrane between the chorion and decidua there is no other trace.

Those who conceive that there is a fusion between the reflexa and vera, are forced to seek for traces of the former membrane next the chorion. They may assume either that the epithelioid layer is the remnant of the decidua, which forces them to leave the fate of the chorionic epithelium unexplained or that the upper stratum of the decidua is the reflexa which is fused with and acquired the same structure as the underlying vera. If my observations on the degeneration of the reflexa are correct, and correspond, as there is sufficient ground to believe they do, to normal conditions, then both assumptions as to the persistence of the reflexa involve the further and very improbable assumption that the degenerated tissue is removed and replaced by fully organized cellular decidual tissue. It is obviously more in accordance with our knowledge of degenerative changes to assume that the hyaline metamorphosis is necrotic and is succeeded by the disintegration and removal of the tissue. This accounts in a satisfactory manner for the absence of the decidua reflexa during the sixth and seventh month. The relations of the membranes at this period have been well described and figured by an admirable observer Dr. G. Leopold, whose views and one of whose drawings have been incorporated by Prof. O. Hertwig in his *Entwickelungsgeschichte* (Third edition, pp. 216-217, fig. 147). Leopold holds that the epithelioid layer is the reflexa, but what has just been said suffices, I think, to show that this view is untenable.

That the membrana decidua reflexa should degenerate and disappear no longer seems strange since recent investigations have shown that in many placental mammals there occurs an extensive pseudo-pathological destruction of the mucosa uteri during gestation. These changes, which are best known in the rabbit (cf. Minot Biol. Centralbl. x, 114) vary considerably in character and are exceedingly remarkable both for their extent and for their numerous modifications, so that we need feel no surprise at the entire destruction of the decidua reflexa in man, nor at form of the destruction being unlike the forms hitherto found in other mammals.

As to the purpose or advantage of the sacrifices of maternal tissue we

are in the dark. The same is true of the causation of the degeneration, although we must regard it as the result of a reflex nervous activity. It is becoming more and more evident that the nerves have a profound influence upon organization, and it is no strained hypothesis which places the structure of the mucosa uteri under the immediate control of the nervous system.

SOME HERPETOLOGICAL NOTES. By O. P. HAY, Irvington, Ind.

[ABSTRACT.]

NOTE on the food-habits of the snapping turtle.

Note on the occurrence of the box-tortoise in the water.

Note on the identity of the two supposed species of Gopher snakes.

Notice of a supposed new species of *Tropidonotus*.

ON CERTAIN SPECIES OF THE GENUS CHOROPHILUS. By O. P. HAY, Irvington, Ind.

[ABSTRACT.]

GIVES descriptions and measurements of specimens of *Chorophilus* to show the identity of *triseriatus* and *nigritus*.

THE DISTRIBUTION OF LAND BIRDS IN THE PHILIPPINE ISLANDS. By Prof. J. B. STEERE, Ann Arbor, Mich.

[ABSTRACT.]

I. HISTORY of expedition to the Philippines.

II. Number of genera and species of land birds.

Number of genera and species of migrating land birds.

Number of genera and species of resident land birds.

Law of their distribution.

EXHIBITION OF DIAGRAMS ILLUSTRATING THE FORMATION OF THE HUMAN SYLVIAN FISSURE. By Prof. BURT G. WILDER, Ithaca, N. Y.

[ABSTRACT.]

These diagrams represent the left side of eight human cerebrums, one adult, one at birth, and the others foetal at as many different ages. All the brains were hardened in the cranium, mostly by alinement. The six foetal brains are enlarged upon one and the same scale.

In addition to the changes by which the insula is gradually concealed more or less completely by the supergyres constituting the several operculums, the diagrams cast doubts upon Herve's recent conclusion that the subsylvian fissure ("horizontal branch of Sylvian") is more constant with primates than the presylvian ("ascending branch"), and also upon the writer's previous determinations of these fissures in the "Reference Handbook of the Medical Science," VIII, figures 4760-4779. In particular there is reason for believing that in figure 4767 the bifurcated fissure between the number 2 and the word *operculum* represents the presylvian only, and that the subsylvian is a short fissure farther ventrad, nearly concealed by the postoperculum but really incising the entire thickness of the supergyre so as to demarcate the preoperculum and suboperculum.

The careful comparison of many well preserved specimens at all ages is needed for the final interpretation of this complex region, physiologically important also as the speech center, and zoologically on account of its deficiency in apes and other mammals.

ACCOUNT OF THE MARINE BIOLOGICAL LABORATORY AT WOOD'S HOLL. By Dr. C. S. MINOT, Boston, Mass.

[ABSTRACT.]

An account was given of the foundation and growth of the laboratory, its position, equipment, and notice of the fauna and flora of Wood's Holl, describing the work of instruction and investigation, which has been carried on there.

THE DESIRABILITY OF ESTABLISHING A BIOLOGICAL STATION ON THE GULF OF MEXICO. By Dr. W. P. WILSON, Philadelphia, Penn.

[ABSTRACT.]

The presentation of a plan for the establishment of a marine biological laboratory upon the Gulf coast of Florida.

NOTES UPON ISOPYRUM BITERNATUM. By C. W. HARGITT, Oxford, Ohio.

NOTES ON PLANTS COLLECTED BY DR. EDWARD PALMER AT LA PAZ, LOWER CALIFORNIA, IN 1890. By J. N. ROSE, presented by F. V. COVILLE, Washington, D. C.

WORK OF THE BOTANICAL DIVISION OF THE DEPARTMENT OF AGRICULTURE.
By F. V. COVILLE, Washington, D. C.

OBSERVATIONS ON THE VARIABILITY OF DISEASE-GERMS. BY THEOBALD
SMITH, M.D., Bureau of Animal Industry, Washington, D. C.

REPORT OF A CASE OF MORBID AFFECTION OF THE EYE IN A CAT, ACCOM-
PANIED BY LOCALIZED DEGENERATION OF THE CORTEX OF THE OCCIPITAL
LOBE OF THE OPPOSITE SIDE. By Prof. G. L. HERRICK, University of
Cincinnati, Ohio.

SECTION H.

ANTHROPOLOGY.

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ADDRESS
BY
FRANK BAKER,
VICE PRESIDENT, SECTION H.

THE ASCENT OF MAN.

THE science of anthropology, one of the younger daughters of human knowledge, is so vast in its scope that to master all of its different ramifications seems a hopeless task. Having for its object the comprehensive study of man, including his origin, his development, and his present condition, its aim is to focus and co-ordinate the general results derived from a vast number of subordinate branches. The philologist contributes information concerning the origin and growth of language and its effect upon civilization ; the mythologist tells of the psychological side of the human mind and traces the rise and progress of religious ideas ; the archaeologist, in order to fix their places in the history of mankind, searches for the remains of peoples long since passed away,—all these depend for their material upon external records, left by tradition, by writing, by sculpture, or by implements and weapons. With greatest care every habitation of man is searched in order to learn from it the details of the life of its former inhabitants.

Within comparatively recent times still another avenue of information has been found, for we have learned that it is not alone by these external records that man's history can be traced, but that important facts may be obtained by studying the constitution of his body ; that the changes and vicissitudes of his existence are recorded on his very bones, in characters long undeciphered but to which the clew has at last been found. My labors have led me more particularly to this department of anthropology, and a con-

cise summary of the main heads of this research may be of value and interest.

The views propounded by Lamarck in the early part of this century, with reference to the modification of living organisms by use and adaptation, have been remarkably confirmed in modern times. Exhaustive researches into the constitution and properties of the cells composing living tissues show that they are subject to continual change, each impulse from without being registered by some small alteration in their physical condition. Impulses of a similar kind continuously acting produce greater changes, and long-continued repetition notably alters even the hardest and most enduring of structures. Thus it is that bones are modified in form by muscular pull, and the surfaces of teeth are shaped by incessant grinding. These alterations are more readily apparent to us because they affect very hard and easily preserved organs, but the effects are equally potent, though not so clearly recognizable, in the softer tissues of the body. Every act of our lives is certainly but surely registered within the marvellous structure of our bodies. Not a muscle can contract without an absolute change in its substance; not a nerve-cell can discharge without some self-destruction.

Most of these changes being very minute and evanescent are quite beyond our power to accurately estimate, and were the increments of change confined to a single lifetime—were each individual to stand only for himself and compelled to earn his experience by the same tedious struggle—use and adaptation would have but little power to mold mankind into races and varieties. But by the action of a law as yet imperfectly understood, the adaptations of each individual are transmitted to its offspring; or, to speak more accurately, the offspring pass through the changes more easily and quickly than the parent did. While each has always to go back to the beginning and commence from the simple blastema of the primitive egg, the younger has the advantage of being able to adapt itself more quickly to its surroundings, provided these have not too greatly changed, and thus starts a little way ahead of its ancestor in the race for life. In consequence of this law changes become cumulative, and a cause acting for a great length of time upon a series of successive generations finally produces a well-marked and easily observed effect in the structure of individuals—changing colors, modifying organs, shaping whole regions of the body.

Again, if, after such changes have been effected, these causes cease to operate and the organs they have shaped are no longer of use, the latter become reduced in size, atrophy and recede, remaining, however, in a vestigial condition for many, many generations as records of the past history of the race, as dolmens and cromlechs certify to former customs, and flint arrow-heads and stone hatchets give evidence of a previous state of civilization.

The human body abounds in testimony of this sort—indications of the pathway up which humanity has climbed from darkness to light, from bestiality to civilization—relics of countless ages of struggle, often fierce, bloody, and pitiless.

These are found in every organ of the body, and each new investigation adds to their number. To enumerate them all would be impossible within the limits assigned me by your patience; I will therefore touch only upon a few of the more striking ones, especially those connected with the modifications of the limbs, with the erect position, and with the segmentation of the body.

The limbs, being organs of support and locomotion, show great variations in the zoölogical series, and the hand of man has long been looked upon as especially significant of his high position in the animal kingdom—one of the chief distinctions between him and the nearest brutes. To a certain extent this is correct. No creature possesses so highly complex and effective an organ for grasping and adjusting objects, and it is preëminently this that has made man a tool-using animal. On comparing a human hand with that of the anthropoids it may be seen that this efficiency is produced in two ways—first, by increasing the mobility and variety of action of the thumb and fingers; second, by reducing the muscles used to assist prolonged grasp, they being no longer necessary to an organ for delicate work requiring constant readjustment. Thus some elements are added and some taken away. Now, according to the theory I have enunciated, the latest elements ought to show signs of their recent origin—to be somewhat imperfectly differentiated and liable to return to their primitive state, while those going out of active use ought to be vestigial, not equal in size or force to muscular organs generally, very liable to variation or disappearance. This is what actually occurs.

Among the new elements is a special flexor muscle for the thumb arising high up on the fore-arm. A very slight examination shows that this muscle has been split off from the fibres of the deep flexor

that bends the terminal joints of the fingers. In most apes the two form a single muscle, and in man the thumb flexor very often shows unmistakable evidence of such origin. In about 10 per cent of persons, part of its fibres pass over and become blended with the parent muscle. Not unfrequently I have seen the two entirely united, returning absolutely to their primitive condition. The deep and superficial flexors of the fingers show signs of a similar relationship, as they frequently blend more or less, tending to revert to the type shown in most lower animals. Indeed, if we go back to embryonic life we find all the muscles of the anterior part of the forearm united in what is termed the pronato-flexor mass, recalling the original condition of musculature in the earliest animals possessing limbs.

In the category of disappearing muscles comes the palmaris longus, an important aid in climbing and grasping. It takes its origin from the upper arm and passes to the hand, where it expands into a large sheet of thick membrane called the palmar fascia, which splits into several slips passing to each finger. The pull of the muscle acts upon all the fingers together, keeping them bent without independence of action. Now in man the fingers have each two separate flexor tendons that can act to a certain extent independently. To ensure their independence they are, at the wrist, enclosed in a remarkable tubular conduit or subway formed by soldering the palma fascia to the wrist-bones. This at once destroys any effective action of the palmaris longus on the fingers and it becomes a flexor of the wrist. This soldering undoubtedly took place because the muscle was no longer required as a finger-holder. Like other organs that after playing a considerable part have come from change of habit to be of but little value, it shows the most astonishing tendency to variation. Not a week passes in a large dissecting room that some curious anomaly is not found in this muscle. Sometimes it is seen almost in its primitive condition, the palmar fascia being comparatively movable and the palmaris longus having some effect upon the flexion of the fingers; oftener it unites wholly or partially with some portions of the pronato-flexor mass or disappears altogether. The disappearance is usually only apparent, however. Regressive structures rarely disappear totally, for on careful search a strip of fascia can usually be found that represents the atrophied and aborted organ.

Since these two examples differ in that the first represents the

development of a new muscle while the second is the atrophy of an old one, we ought to find racial differences corresponding to these two conditions. Our studies of racial anatomy are as yet far from sufficient to give us certain information upon these points, and I would especially avoid generalizing upon too meagre data. It has, however, appeared to me that in negroes the palmaris longus is more inclined to assume its primitive type—that is, to be less likely to vary—while the long flexor of the thumb is, on the contrary, more inclined to be partially if not wholly united with the deep flexor of the fingers.

Connected intimately with the hand are the other portions of the thoracic limb that carry it from place to place. Here again we may note many points indicating a progressive development of the member. When the arm is naturally and easily bent at the elbow it does not carry the hand to the shoulder, as might be expected, but towards the mouth. The reason for this is that the articular surfaces of the elbow-joint are not cut horizontally across the axis of the humerus but inclined at an angle of about 20° . This obliquity does not occur in the foetus and is less in Bushmen, Australians, and the anthropoid apes. It is associated with another peculiarity; indeed, may be said to be caused by it. This is a twisting of the humerus on its axis, which occurs markedly in the higher races. If we hold up endwise the humerus of a European we see that the longest diameters of the upper and lower ends very nearly coincide. In the negro we find the lower diameter turned more towards the body; still more in the anthropoid apes, and again more as we descend the scale. Embryology teaches that the humerus was formerly set so that the hollow of the elbow looked inward rather than forward, and it seems, therefore, that, as the functions of the limb became more various, the lower end of the bone gradually twisted outward around the long axis until its diameter described a considerable arc. This turned the hand with the palm to the front, extended its range and adapted it for a wider usefulness. Greater twist is found in the right humerus than in the left and in the humeri of modern times than in those of the stone age. As the torsion increased some provision became necessary for carrying the hand easily across the body to the mouth. This was effected by the inclination of the trochlear surface of the elbow-joint already adverted to.

Many movements of the arm in man are produced by muscles

acting upon the shoulder-blade or scapula. As the hand was turned outward and a wider range given, these increased in extent and importance, and the scapula accordingly widened out at its vertebral border in order to give a more extensive attachment for muscles. In order to accurately estimate this change the ratio of the breadth to the length of the scapula is taken. This ratio, called the scapular index, is highest among the white races, less in the infant, in negroes, and in Australians, and still less in anthropoid apes. It is significant also that the vertebral border of the scapula is the last to form in the foetus. We have, therefore, three modifications — the torsion of the humerus, the inclination of its trochlear surface, and the scapular index — all depending upon each other, all varying together *pari passu*, and all showing a progressive development both in the individual and the race.

Muscle is composed of one of the most highly organized and expensive tissues of the body. Unless fed constantly with a great supply of blood to keep up its active metabolic changes, it quickly wastes, functional activity being absolutely necessary to its proper maintenance, as any one knows who has seen how rapidly the muscles of an athlete diminish when he goes out of training. If from accident or change of habit its use altogether ceases, its protoplasm is gradually removed, its blood-supply diminishes, and it shrinks to a mere band or sheet of fibrous tissue. Changes of function may therefore affect the form of muscles, one portion becoming tendinous or fascia-like; may even cause them to shift their places by inducing a development on one side and an atrophy on another, or disappear altogether, replaced by fascia or ligament. A similar regression may take place in bone and cartilage, a high grade, actively metabolic tissue, difficult to maintain, being replaced by a low grade one comparatively slow to change. It is, therefore, not unusual to find that muscles, bones, and cartilages performing important functions in some animals are represented by vestigial structures in those higher in the scale. Our conclusions on this subject are confirmed by finding occasional instances where the hereditary tendency has been greater than usual and the parent form is produced more or less completely in the higher animal. The palmar fascia at the distal end of the palmaris longus, to which allusion has been made, represents a former muscular portion, relics of which probably remain as some of the small thumb muscles.

Another interesting instance is the epitrochleo-anconeus, a small

muscle at the elbow-joint, used in apes to effect a lateral movement of the ulna upon the humerus. In man the ulna has become so shaped that the lateral movement is almost totally lost, and the muscle has accordingly degenerated, being represented by a strip of fascia. Very often, however, a few muscular fibres are still found in this situation.

Several minor peculiarities that remind us of primitive conditions occur in the region of the humerus. Occasionally a supracondyloid process is found throwing a protecting arch over the brachial artery and median nerve; in this resembling the supracondyloid foramen of marsupials. Struthers found this to be hereditary, occurring in a father and four children. A perforation of the olecranon fossa may probably be regarded as a reversion towards the condition of anthropoid apes. This frequently occurs in South African and other low tribes and in the men of the stone age. Recently Dr. D. S. Lamb has found it remarkably frequent in prehistoric Indian humeri from the Salado Valley, Arizona.

While the region of the hand and fore-arm indicates increase of specialization, the upper part of the limb generally testifies to a regression from a former more highly developed state. The anatomy of the flying apparatus of a bird shows a series of muscular, ligamentous, and bony structures connected with its upper arm far beyond anything ever seen in man. The coracoid bone, a very important element of the shoulder girdle in birds, has become reduced in man to a little vestigial ossicle that about the sixteenth year becomes soldered to the scapula as the coracoid process. The muscles arising from this—pectoralis minor, coraco-brachialis, and biceps—are structures represented in birds by strong, flying muscles. The subclavius, a little slip ending at the clavicle, appears to have formerly passed to the coracoid bone or to the humerus and been employed in arm movement. The pectoralis major appears to represent what was formerly a series of muscles. All these have a tendency to repeat their past history, and the number of variations found among them is legion. The biceps shows traces of its former complexity by appearing with three, four, or even five heads, by a great variety of insertions, by sending a tendon outside the joint capsule instead of through it, as is the rule. The pectoralis major may break up into several different muscular integers, inserted from the shoulder capsule down to the elbow. The coraco-brachialis shows the same instability, and by its behavior clearly indicates its derivation from a much larger and more extensive muscular sheet.

Not less significant are the ligaments about the shoulder. Many of these appear to be relics of organs found active in animals lower in the scale. Thus the coraco-acromial ligament spanning over the shoulder-joint is probably a former extension of the acromion process; the rhomboid, conoid, trapezoid, and gleno-humeral ligaments represent regressive changes in the subclavius muscle, the coraco-humeral ligament, a former insertion of the pectoralis minor. Bands of the deep cervical fascia alone remain to testify to the former existence of the levator claviculae, a muscle present in most mammals and used to pull forward the shoulder girdle when walking in a quadrupedal position. In negroes I have frequently found it more or less complete. A fibrous strip uniting the latissimus dorsi to the triceps is all that remains of an important muscle, the dorso-epitrochlearis, passing from the back to the elbow or fore-arm, used by gibbons and other arboreal apes in swinging from branch to branch. Testut found this fully developed in a Bushman. I have myself seen various muscular slips that must represent some portion of it, and authors generally describe it as occurring in five or six per cent of individuals.

The hind limbs of apes are popularly thought to be remarkably specialized. The term quadrumanæ or four-handed, is used to characterize the class; yet it is quite true that this term involves a false conception. No animal has four exactly similar feet, still less four hands. The feet of the ape differ widely from hands; the great toe is not really opposable like the thumb, but merely separable from the others and differently set, so as to afford a grasp like that of a cramp-iron. The gibbon alone has a small muscle of the foot that may be compared with the opponens of the thumb. That these peculiarities are also shared by man to some extent is also well known. It is quite possible to train the toes to do a certain kind of prehensile work, even to write, cut paper and sew. A baby not yet able to walk can often pick up small objects with its toes. Compare the marks caused by muscular action on the sole of a baby's foot with those on the hand, and it will be seen that there are distinct signs of this prehension. Even the opponens hallucis of the gibbon is not infrequently found in man. The foetal condition of the foot also approaches that of the apes, the heel being shorter and the joints so arranged that the sole can be easily turned inward. In the ape the first or great toe is turned backward and outward by shortening its metatarsal bone and setting it obliquely upon the ankle. This shortening and obliquity also occur in the foetus; the adult condi-

tion, in which the metatarsal bone is lengthened and set straight so as to give a longer and firmer internal border to the foot, being gradually acquired. Many savage tribes still use the foot for climbing and have a shorter metatarsal, a wider span between the first and second toes, and greater ease in inverting the sole. Connected with this ease of inversion should be mentioned a peculiar, ape-like form of the tibia that occurs in people of the stone age, in the mound-builders, and in some American Indians. This is a flattened, sabre-like condition of the bone known as platycnemy. It is apparently to give greater surface of attachment and resistance to the pull of the tibialis anticus, the principal muscle that turns the sole inward. It is interesting to note that this peculiarity is much more marked in some early human skeletons than in any of the anthropoids.

The poet says that while other animals grovelling regard the earth, Jupiter gave to man an uplifted countenance, and ordered him to look heavenward and hold his face erect towards the stars.

“Pronaque cum spectent animalia cetera terram,
Os homini sublime dedit, cœlumque tueri
Jussit, et erectos ad sidera tollere vultus.”¹

Ovid, Metamorphoses: I, 84-86.

The erect position is, however, gradually acquired. As in the sphinx's riddle, we literally go on all fours in the morning of life, and the difficulty that an infant experiences in learning to walk erect is strong evidence that that is an accomplishment acquired by the race late in its history. We ought, if this is the case, to find in the human body indications of a previous semi-erect posture. There is a vast amount of evidence of this character, and I can only sketch the outlines of it.

The erect position in standing is secured by the shape of the foot, by the attachment of strong muscles at points of severest strain, and by the configuration of the great joints which permits them to be held locked when a standing posture is assumed. All these features are liable to great variation; they are less marked in children and in the lower races. Let us examine them somewhat more carefully.

¹Compare Milton:

“A creature who not prone
And brute as other creatures, but endued
With sanctity of reason, might erect
His stature, and upright with front serene
Govern the rest, self-knowing.”

Paradise Lost: VII, 506-510.

The Caucasian type of foot is evidently that best adapted for the erect position. The great toe is larger, stronger, and longer than the others, making a firm support for the inner anterior pier of the arch formed by the bones—an arch completed by a well-developed heel and maintained by a strong dense band of fascia and ligament binding the piers together like the tie-rod of a bow-string truss—thus producing a light and elastic structure admirably adapted to support the weight of the body and diminish the effect of shocks. In the lower races of man all these characters are less marked. The great toe is shorter and smaller, the heel-bone less strongly made, the arch much flatter. This flattening of the arch produces the projection of the heel found in some races.

The muscles required for maintaining the erect position are those which from our predilection for human anatomy we are apt to call the *great extensors*, overlooking the fact that in other animals they are by no means as well developed as in man. Being required at the points of greatest strain, all are situated on the posterior aspect of the body—the calf, the buttock, and the back.

A very slight examination of any lower animal will show how strikingly it differs in the muscular development of these regions. The great muscle of man's calf, the triceps extensor suræ, is formed by the welding together of some four muscles separate in many lower forms. Varieties are found in man showing all grades of separation in these elements. One of the muscles, the plantaris, was formerly a great flexor of the toes, the plantar fascia representing its distal extent. Like the palmaris of the arm it lost its original function by the welding of the fascia to the bones to secure the plantar arch, and its functions being then assumed by other muscles it began to dwindle, and is now represented by a mere vestigial rudiment of no functional value. It is well known that the lower races of men have smaller calves than Europeans. Again, it should be noted that as the erect position is assumed the muscles required for the flexion and independent action of the toes become reduced in character. A comparison with other forms shows that some of the small muscles now confined to the region of the foot formerly took their origin higher up, from the bones of the leg. Losing in functional importance, they have dwindled in size and gradually moved downward.

The great glutæi muscles of the buttock find their highest development in man. They are subject to similar variations. Certain

muscles of this region, normal in apes, are occasionally found in man—a separate head of the great glutæus, derived from the ischium, and the scansorius, or climbing muscle, that assists the great flexor of the thigh (the ilio-psoas), may be mentioned.

The enormous size and complexity of the muscles of the back in man are well known. The erector of the spine fills up the vertebral grooves and sends up tendons along the back, like stays supporting the masts of a ship. The mass of this muscle is comparatively less in anthropoids.

Notwithstanding all these powerful muscles, it would be impossible to retain the erect position for any great length of time were we to depend upon them alone, for it requires as before stated, a great expenditure of force to keep a muscle in active use. It becomes rapidly fatigued and then loses its power, as any one may prove by standing in any constrained position, even "in the position of a soldier," for half an hour. To provide against this a beautiful arrangement of joints and ligaments has been developed.

When in the erect attitude the ankle-joint is so arranged that its bones are in a position of greatest stability, and the center of gravity is so adjusted that it falls directly upon it. This reduces to a minimum the amount of muscular force required to keep the body erect. At the knee the center of gravity falls a little in front of the axis of the limb, and the back and sides of the joint are provided with check ligaments or straps that hold the joints locked in a position of hyper-extension, so that no muscular force whatever is used to maintain it. These ligaments are regressive structures, being vestiges of former insertions of muscles near the joint. At the hip a similar condition occurs, the center of gravity falling behind the joint and the whole weight of the trunk being hung upon the ilio-femoral ligament. This structure is much more marked in man than in other mammals, and is found to vary considerably in its size and strength.

The spinal column has been remarkably modified to adapt it to the erect position. Before the fifth month of uterine life the whole spine describes a single, large, dorsally directed curve like that of the quadruped, arranged to accommodate the viscera. As this would be incompatible with the erect posture, two additional curves in the opposite direction are formed—one in the region of the loins just where the center of gravity would begin to fall forward, another in the neck to counteract the heavy and unstable weight of the head.

These curves are gradually acquired. While possessed by all races, and in a less degree by the higher apes, they arrive at their highest development in Europeans. Careful measurements show that the shapes of the vertebræ have been gradually modified. There is no abrupt transition from the spine of the lowest savages—Australian, Bushman, Andaman—to that of the gorilla, gibbon, and chimpanzee, and the lumbar curve of the lower races of men is much better adapted to running in a semi-erect position through the jungle or bush.

There is also evidence that the posterior limbs have moved forward upon the spinal column in order that the erect position may be assumed with less effort. In man there are between the skull and the sacrum twenty-four vertebræ. The other primates have usually twenty-six, although the gorilla, chimpanzee and orang, agree with man. Now in foetal life the attachment of the hip-bones to the sacrum commences from below upward. Union first occurs with the third sacral vertebra, leaving twenty-six presacral, then advances forward, the first sacral uniting last of all. The hip-bones actually move up along the spine a distance of two segments. Occasionally this shifting is carried still farther, and but twenty-three presacral vertebræ are left. Anomalies caused by an arrest of development at some stage of this process are not at all infrequent. The most common is the want of union between the hip-bones and the first sacral vertebra, thus producing apparently six lumbar vertebræ. A most beautiful specimen of this anomaly was found last winter in my laboratory.

The spine is sustained erect by stringing from vertebra to vertebra numbers of short ligaments that reduce to a minimum the muscular exertion required to support it. These are particularly numerous between the spines along the great dorsal curvature. Some of these ligaments are replaced by small muscles, very inconstant and variable, the survivals of a whole system of musculature that had for its object the moving of the separate joints of the spine, one upon another.

The head is also much modified by the erect position. In quadrupeds its suspension requires an extensive apparatus, a large, strong, elastic strap—the ligamentum nuchæ—passing from the tips of the thoracic vertebræ to the occiput, sending processes to all the neck vertebræ involved in the strain. Though need for it has in great degree ceased, since the head has become poised in such a

way as to involve but little expenditure of muscular force, yet relies of this great suspensory apparatus remain in man's neck in the form of thickened fascial bands.

The arrangement of the great foramen of the skull that transmits the central axis of the nervous system, the spinal cord, is necessarily different in an animal carrying its head erect. The foramen would naturally tend to be set forward, more under the center of gravity, and its inclination would be more nearly horizontal. Here again we see that the ideally perfect form is more nearly approached in the civilized races. It is never quite realized, and indeed the whole skull and its contents evince markedly that they are still undergoing an evolution. Again the lower races show variations that unite them with the anthropoids. While a negro may have a foramen magnum inclined 37° to the horizontal, the orang may fall to 36° .

But it is not only in this way that we get evidence that the erect position has been gradually acquired. Since gravity plays an important part in the functions of the visceral and circulatory systems, any marked change in the line of equilibrium must necessarily be accompanied by disturbances. These disturbances, to a certain extent, conflict with the acquirement of the position, as they weaken the animal. In the course of time the body may perhaps become adapted to the changed conditions, but before that perfect adaptation takes place there is a period of struggle. There is abundant evidence that such a struggle has occurred and is yet going on; the adaptation being as yet far from complete.

The most striking and important of these adaptations concerns the pelvis. When the erect posture is assumed, the weight of the viscera being thrown upon this bony girdle, it becomes adapted for their support by becoming more fixed and dish-like in shape. This is naturally more pronounced in the female, since with her the pelvis must bear the additional weight of the pregnant uterus. It is evident that a solid, unyielding, laterally expanded ring of small aperture would give the most effective support in the erect position, but it is equally clear that with any such structure parturition would be impossible. In the quadruped the act of parturition is comparatively easy, the pelvis offering no serious hindrance. The shape of the female pelvis is therefore the result of a compromise between two forms—one for support, the other for ease in delivery. When we reflect that along with the requirement of the erect position the size

of the head of the child has gradually increased, thus forming still another obstacle to delivery and to the adaptation which might otherwise have taken place, we can realize how serious the struggle has been, and no longer wonder that deaths in child-birth are much more common in the higher races, and that woman in her entire organization shows signs of having suffered more than man in the upward struggle.

In no other animal is there shown such a distinction between the pelvis of the male and that of the female—a distinction that increases as we ascend the scale. While the amount of individual variation is great, we yet see, particularly in the pelvis of the Andaman Islanders and of the Polynesian races, distinctly simian characters. The scanty material at hand indicates that a similar transition occurred between the modern and prehistoric types. The approximation of the infantile and simian forms is well known.

The pelvis alone does not suffice to support the viscera. In quadrupeds the whole weight is slung from the horizontal spine by means of a strong elastic suspensory bandage of fascia, the tunica abdominalis. The part of this near the thorax has in man entirely disappeared, being no longer of any use. In the groin it remains to strengthen the weak points where structures pass out from the abdominal cavity. That it is often insufficient to withstand the great pressure is testified by the great prevalence of hernia, another sign of imperfect adaptation. The frequency of uterine displacements, almost unknown in the quadruped, has also been noted, and it is significant that one of the most effective postures for treating and restoring to place the disturbed organ is the so-called "knee-elbow position," decidedly quadrupedal in character.

Many other indications are found in the viscera. The urinary bladder is so arranged in man that any concretions do not gather near the opening of the urethra where they might be discharged, but fall back into the cul-de-sac at the base, where they enlarge and irritate the mucous lining.¹ The cæcum, with its vermiciform ap-

¹ Since writing the above Mr. William B. Taylor has called my attention to the following remarkable passage in the works of Dr. Erasmus Darwin. It occurs in his "Temple of Nature," Canto 2, foot-note to line 122.

"It has been supposed by some that mankind were formerly quadrupeds as well as hermaphrodites; and that some parts of the body are not yet so convenient to an erect posture as to a horizontal one; as the fundus of the bladder in an erect posture is not exactly over the insertion of the urethra; whence it is seldom completely evacuated, and thus renders mankind more subject to the stone than if he had preserved his horizontality."

The preface to this poem is dated Jan. 1, 1802.

pendage, a vestigial organ finding its proper functional activity far below man, is so placed in quadrupeds that the action of gravity tends to free it from faecal accumulations. In man this is not the case, and as a consequence inflammation of this organ or its surrounding tissues, very serious and often fatal, is by no means rare. It may be noted that the ascending colon is obliged to lift its contents against gravity, and that in a lowered state of the system this might very readily induce torpidity of function. The gall bladder in quadrupeds also discharges at an advantageous angle. In man, although the difference is slight, it appears to be sufficient to cause at times retention and consequent inspissation of the bile, leading to the formation of gall-stones.

The quadruped's liver hangs suspended from the spine, but as the erect attitude is assumed it depends more and more from the diaphragm. The diaphragm in its turn develops adhesions with the fibrous covering of the heart, which is continuous with the deep fascia of the neck, so that in effect the liver hangs suspended from the top of the thorax and base of the skull. This restricts in some degree the action of the diaphragm and confines the lungs. This must have an effect upon the aeration of the blood and consequently upon the ability to sustain prolonged and rapid muscular exertion. An extra lobe of the right lung that in animals intervenes, either constantly or during inspiration, between the heart and the diaphragm, is occasionally found in a vestigial state in man.

The vascular system abounds in evidences that it was primarily adapted to the quadrupedal position. By constant selection for enormous periods of time the vessels have become located in the best protected situations. It is scarcely possible to injure a vessel of any size in the animal without deeply penetrating the body or passing quite through a limb. In man, on the contrary, several great trunks are comparatively exposed, notably the great vessels of the thigh, those of the fore-arm, and of the ventral wall.

The influence that gravity has upon the circulation is well known. The horizontal position of the great venous trunks favors the easy flow of blood to the heart without too greatly accelerating it. Man, in whom these trunks are vertical, suffers thereby from two mechanical defects—the difficulty of raising blood through the ascending vena cava, whence come congestion of the liver, cardiac dropsy, and a number of other disorders, and the too rapid delivery through the descending cava, whence the tendency to syncope

or fainting if for any cause the action of the heart is lessened. Clevenger's admirable discovery that the valves of the veins are arranged for a quadrupedal position should also be mentioned here. Evidently intended to resist the action of gravity, they should, to be effective, be found in the large vertical trunks. But in the most important of these they are wanting; hence are caused many disorders arising from hydrostatic pressure, such as varicose veins, varicocele, haemorrhoids, and the like. Yet they occur in several horizontal trunks, where they are, so far as we know, of no use whatever. Place man on all fours, however, and it is seen that the entire system of valves is arranged with reference to the action of gravity in that position. The great vessels along the spine and the portal system being then approximately horizontal do not require valves, while all the vertical trunks of considerable size, even the intercostal and jugular veins, are provided with them. A confirmation of this view is found in the fact that the valves are variable in character and tend to disappear in the veins where they are no longer needed.

Every animal possessing a back-bone may be said to consist of a series of disc-like segments, arranged on a longitudinal axis. These segments are originally similar in character, but become specially modified in innumerable ways to meet the needs of the individual. Anatomists conclude, upon surveying the whole field, that this indicates a derivation of the vertebrates from some form of the annelid worms, among which a single unit produces by successive budding a compound longitudinal body. This view is fully confirmed by the behavior of the human embryo.

The number of the segments varies considerably, rising sometimes to as many as three hundred in some fishes and reptiles, and being generally greater in the animals below man. There are many indications, however, that in man, segments formerly possessed have disappeared. Leaving the skull for the present out of account, there are in the adult thirty-three or thirty-four vertebrae that may be held to represent these segments; the additional vertebra, when it occurs, almost invariably belonging to the coccygeal or caudal series. In the human embryo thirty-eight segments can at one time be made out. Four or five of these generally disappear, but cases are by no means wanting in which they remain until after birth and constitute a well-marked free tail. In one case, carefully examined and described by Lissner, a girl of twelve years had an appendage

of this character 12.5 centimeters long. Other observers, probably less careful and exact, report much greater lengths. From some observations it would appear that abnormalities of this kind may be transmitted from parent to offspring.

Dr. Max Bartels recently collected from widely scattered literature reports of 116 actually observed and described cases of tailed men. In thirty-five instances authors reported such abnormalities to be possessed by an entire people, they themselves having observed certain individuals. These cases are scattered throughout the whole of the known globe and extend back for a thousand years. When we consider that the authenticity of many cases is beyond question, and that the number that escaped accurate observation and report must be much greater, we can see that we are not dealing with so rare a phenomenon as would at first be supposed.

Other regressive structures are abundant in this region. The spinal cord in its earlier state extended the entire length of the vertebral canal. In the child at birth it occupies only 85 per cent of that length; in the adult 75 per cent. This is due mainly to the more rapid growth of the spine. There stretches, from the lower end of the cord down to the very end of the spine a small thread-like structure, the filum terminale, a degenerated vestige of the lower caudal part of the spinal cord. Wiedersheim suggests that the frequent occurrence of degenerative disorders in the lower end of the adult cord may be due to a pathological extension of the normal atrophy. Rauber found in this region traces of two additional pairs of spinal nerves. The vessel that runs down in front of the sacrum and coccyx corresponding to the caudal artery of quadrupeds shows signs of a former more extensive distribution, as it ends in a curiously convoluted structure known as the coccygeal gland, containing vestiges of vascular and nervous tissues. Traces of caudal muscles still remain, notably the ischio-coccygeus, which in animals moves the tail sidewise, and the anterior and posterior sacro-coccygeus, for flexing and extending it. Occasionally the agitator caudæ is found as a muscular slip passing from the femur to the coccyx. These muscles cannot be of any value in man, as the coccyx is practically immovable. At the point where the end of the spine was primarily attached to the skin a dimple is formed by regressive growth, and here the direction of the hairs also shows an aborted organ.

Another interesting condition connected with segmentation is

the varying number of ribs. Most mammals have more ribs than man, and as we descend in the scale they continue to increase. A study of development indicates that a rib is probably to be considered as an integral portion of a vertebra. As the arch of a vertebra encloses the central nervous system, so the ribs enclose the visceral system. If this be correct they ought to be found throughout as far as the body cavity extends. This is really the case. They exist in the neck as the anterior bars of the transverse processes, in the loins as the transverse or costal processes themselves, in the sacrum welded together into what are known as the lateral masses. A great number of considerations derived from comparative anatomy, from embryology, and from variations found in the adult combine to support these conclusions.

Nothing would seem less likely at first sight than that the capacious expanded brain-case or skull with its complicated structure should be composed of segmental pieces like the vertebræ; yet there is no doubt that the poet Goethe was on the right track when he made that important generalization. The details of the segmentation are very far from being worked out, but a vast amount of evidence indicates that the general conclusion is correct.

Since the predominant necessity in the construction of the skull is to afford a protection for the brain, we need not be surprised to find that it is very greatly modified in man. Enormous labor has been bestowed upon craniology in an attempt to separate definitely the races of men as well as to connect them with the lower forms. The success in establishing races has not been such as was anticipated. A constant intergrading of forms defies all attempts at a hard and fast classification. We also see types that intergrade between anthropoids and man, and find abundant evidence that the human skull was derived from a form similar to that of still lower mammals.

At first man's skull seems to be much simpler than the typical form. The bones are fewer and less complicated. But follow back the course of development and we find the bones separating—the frontal into two pieces, the occipital and temporal each into four, the sphenoid into eight, repeating what we find as we descend the vertebrate scale.

Many of these peculiarities may remain throughout life. Such are the interparietal bone, found very frequently in ancient Peruvian and Arizonian skulls; the division of the frontal and temporal

bones each into two, the persistence of the intermaxillary bones and of that division of the cheek or malar bone known as the os-japonicum. Even the cleft palate, a deformity and a defect in man, merely reproduces a state natural to some of the lower mammals.

There are also present structures that are homologous with the so-called visceral arches represented in the thorax by ribs. Such are the lower jaw, the hyoid bone, and the thyroid cartilage. A study of the embryo shows us that these are portions of a series of bars primitively arranged on the plan of the branchial apparatus of the water-breathing vertebrates. Each bar has its appropriate skeleton and vascular supply, and is separated from the contiguous ones by a cleft that at first passes entirely through the soft tissues and communicates with the primitive visceral cavity. These clefts may persist and cause serious deformities. The skeleton of the mandibular and hyoid bars is remarkable as containing indications of elements present in the lower vertebrates. In fishes the lower jaw articulates with a large bone apparently not found in mammals, but on tracing carefully the development of the mammalian skull it is found that this bone is represented by the incus, one of the minute ossicles of the ear. In the foetus the primitive lower jaw, in the shape of a bar of cartilage, actually extends into the ear cavity and the upper end of it remains as the malleus. Relics of the hyoid or second branchial arch are also found—the styloid process of the temporal bone being one of them.

The capacity of the cranium is usually held to distinguish man remarkably, yet the lowest microcephali approach the apes in this respect, and the lower races have unquestionably smaller brains than the higher. As far as can be judged, there has also been an increase in average capacity during historic times. One fact pointed out by Gratiolet is very significant. In monkeys and in the inferior races the ossification of the sutures commences at the anterior part of the head, while in Europeans these sutures are the last to close. This would indicate a greater and longer continued increase of the frontal lobes of the brain.

The same remarks may be made concerning the facial angle and prognathism. While by none of the different angles proposed have we been able to definitely separate distinct races, yet we find that the angle of the lower races and of microcephali approaches that of the anthropoids, and that as the capacity of the skull has increased the jaw has been thrust back under it to support the weight.

This shortening of the jaw gives the characteristic expression of the civilized face. We at once recognize a brutal physiognomy by the projection and development of the great masticating apparatus, used in most animals near man as a formidable weapon of defence. The shortening has produced some very remarkable changes. It has shoved the third molar or wisdom tooth so far back that it is crowded against the ascending part of the jaw, thereby occasioning disturbance and trouble in its eruption. Being no longer practically useful, it tends to disappear, and many people never cut any wisdom teeth. Among the Australasians, on the contrary, a fourth molar is not infrequently found, and rarely in European skulls. Evidences also exist of a lost incisor in the upper jaw on each side. Dental follicles form for it and usually abort, but occasionally the tooth appears fully developed in the adult. The great canines, or eye-teeth, used in apes and other animals for tearing and holding, are in them longer and larger than the other teeth, and room is made for them in the opposite jaw by leaving an interval, called the diastema, between the canine and the tooth next to it. These large projecting canines have disappeared in the normal human skull and the diastema has accordingly closed up. Yet it is by no means uncommon to see the whole arrangement reappear, especially in low-type skulls. Projecting canines, or "snag teeth," are so common in low faces as to be universally remarked, and would be often seen did not dentists interfere and remove them. It may be noted also that the muscle that lifts the lip from over the canines and bares the weapon often reappears in man and is used in snarling and disdainful expressions.

Many details of structure of the skull point in the same direction. Occasionally the occipital bone has a third condyle as in some other mammals or a large lateral projection like that of a vertebra, the paramastoid process, or indications of a separate centrum (*os bastioticum* of Albrecht). It may have interiorly a hollow (*fossette vermicienne*) for the vermiform process of the cerebellum, and exteriorly a large transverse ridge (*torus occipitalis*) for the insertion of the muscles of the nape. All these peculiarities are more frequent as we descend the scale, whether we regard the lower races of man, microcephalic individuals, or lower animals. Like many of these atavistic features they are also more common among the criminal classes.

I have omitted the discussion of many important structural fea-

ures that mark various stadia in man's ascent. From the muscular system alone there could be adduced a very great number of instances of the survival of primitive forms and of progressive variations, particularly in the development of the muscles of the face and breast. In the osseous system also there are many such, among which may be mentioned the episternal bones, the central bones of the wrist and ankle, and the *os acetabuli*. The exact significance of these is still under discussion, as is also the question of supernumerary digits that sometimes appear on the hands and feet.

Additional instances might be drawn from the visceral system. The larynx contains small throat pouches like the great air sacs of the anthropoids. The pharynx of the embryo is lined with cilia like that of the very lowest vertebrates. Traces of the primitive intestine are shown by the peculiar distribution of nerves and the folding of the peritoneum. The liver and spleen both occasionally indicate a previous simpler condition, and the intestine has sometimes diverticula of no functional use—indeed, likely to be disadvantageous—yet pointing to a previous state. These anomalies never occur at random, but can be explained consistently upon the theory of reversion.

The genito-urinary system abounds in them. The uterus may have two cavities, as in many quadrupeds, or approach that condition by being bicornuate, as in apes, and a great variety of other vestigial structures occur, all pointing back to an original neutral condition, before the sexes were differentiated.

In the nervous system there is no lack of instances. Our studies of the brain are as yet far from complete—indeed, we seem to be only at the threshold of a reasonable knowledge of the nervous centers—and the crowd of names, the inextricable maze of synonymy that now obscures that region is only a mark of our ignorance. It is a case of "*omne ignotum pro mirifico*"—ignorant of the true value of the parts we examine, we have named even the most insignificant details of structure. Perhaps one of the most interesting results of modern research is the conclusion that the psychic life of our ancestors must have been different from our own, since they possessed organs of sensation differing in degree and probably in kind. The sense of smell as indicated by the size of the olfactory bulbs of the brain is decreasing in acuteness. The foetal brain possesses comparatively larger bulbs, as do also the brains of lower races and of anthropoids. The sense, being no longer re-

quired for the preservation of the species, is slowly becoming dulled. Jacobson's organ, a curious structure found in many mammals, combining in some unknown manner the olfactory and gustatory senses, occurs in a vestigial state in man, and the duct connecting it with the mouth yet remains in the anterior palatine canal. The pineal and pituitary bodies of the brain probably represent obliterated sense organs, the former being an eye, the latter having some connection with the pharynx. Our other senses have also been modified. The eye has a rudimentary third eyelid, such as birds and lizards possess, covered with minute hairs. The external ear shows signs of derivation from the pointed ear of quadrupeds and abounds in vestigial muscles such as they use for controlling and directing it.

From this rapid sketch it will be apparent to you that the evidence that man's path upward has led along the same route traveled by other animals is now very powerful in its cumulative weight. By no other argument can we satisfactorily explain the bewildering maze of resemblances; yet when called upon to fix the exact line by which we have reached our present estate we at once meet with serious difficulties. It is a popular misconception that there has been a regular chain-like series, with now and then a "missing link." The various races of men and the anthropoids are merely one branch of the great tree Yggdrasil, that overshadows the whole earth and reaches up into heaven. The individuals that we compare occupy the terminal twigs of that branch, being not related directly but only as springing from a common stock. The fact that resemblances occur does not necessarily prove a lineal descent but rather a common ancestry. The races of man arose far back in prehistoric night. Each in its own way fought the struggle for existence. Favored more by climate, the Caucasian appears to have attained an intellectual superiority; yet it should not be forgotten that the others also excel, each in its own special way. The white races endure with difficulty the climate of the tropics, and without help would starve in the Australian bush and the Arctic ice-fields.

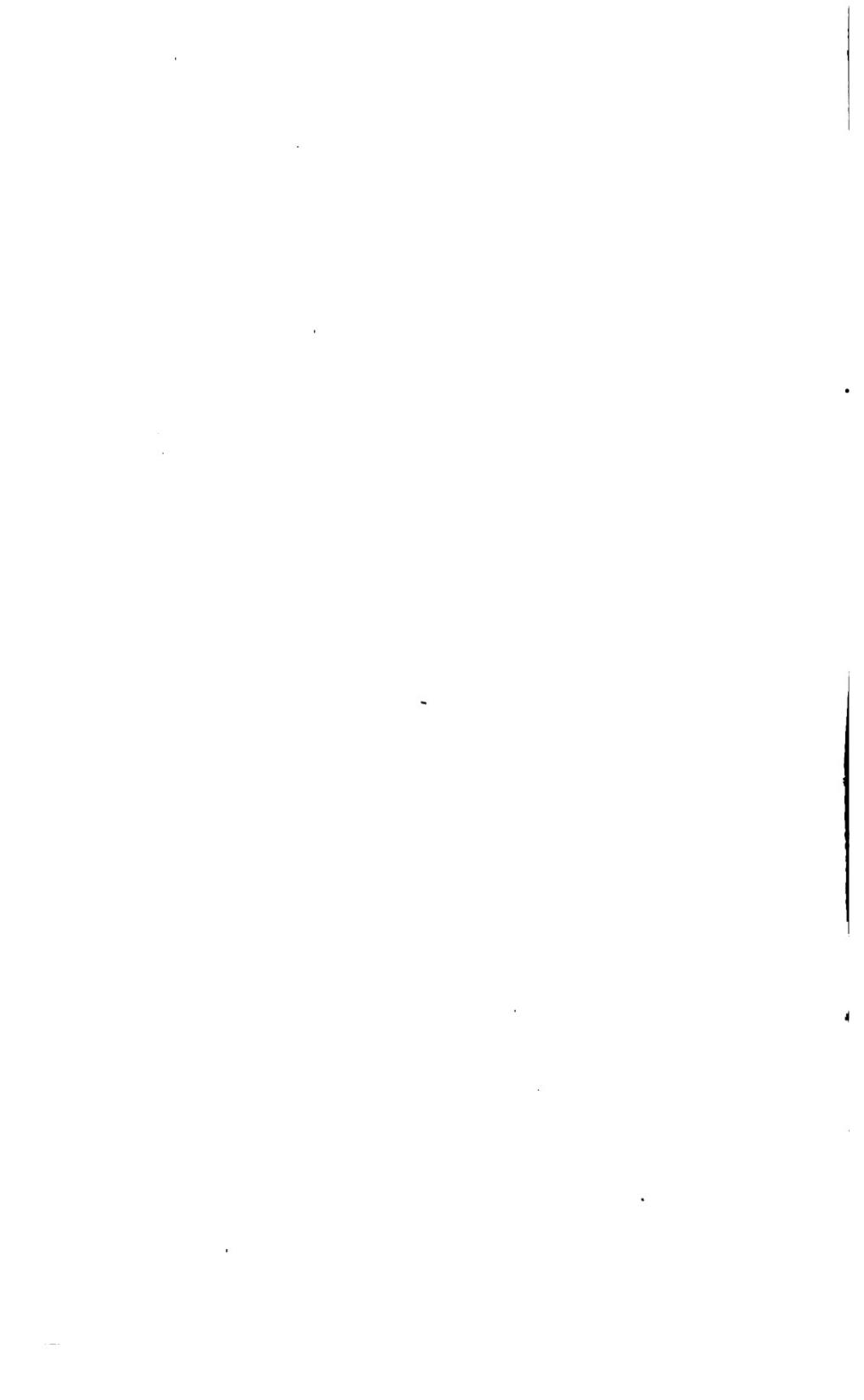
Notwithstanding all that I have said concerning reverisive characters, we yet have hardly sufficient structural grounds for separating the races of man. Different varieties of the Caucasian race show marked variations. Between the lowest and most brutalized laborers and the cultivated and intelligent classes there exist anatomical differences as great as those which separate the white and

the negro. The rapid change in the African races, remarkably shown in America in the three generations now before us, is a more conclusive proof of inferiority, as it indicates that they have not had time to acquire fixed characters.

Again, as to the anthropoids, it is evident that they have widely diverged from man, and that none represent the primitive ancestor from which all were derived. The comparison of a human skull with that of an adult gorilla or chimpanzee is very striking. On the one hand we see all the structural features subordinated to the necessity of forming a capacious receptacle for the brain; on the other, a similar subordination for producing an effective fighting apparatus—jaws, teeth, and ridges for the insertion of powerful muscles. In one, intelligence predominates; in the other, force. The skulls of the young of all these species show, however, much greater resemblances than those of adults. This seems to indicate that there must have been a primitive common type from which all have diverged. Savages when ill-fed and living in unfavorable conditions may simulate the habits of anthropoids, and this has an effect upon their physical structure, yet not on that account should we too readily accept their close relationship.

In this summary, I have purposely refrained from any discussion of the physiological phenomena that necessarily accompany anatomical structure. Yet these are most important. Anatomy and physiology are inseparable, each being dependent upon the other. The results of the erect position, of increased size of brain, of greater specialization of limbs, are almost incalculably great; so great that they affect the whole life of the animal—control his habits, direct his actions in war and in the chase, and finally mold peoples, nations, and races.

As Cuvier was able to deduce an animal's habits from the shape of his teeth, so we may speculate as to man's past and future from an examination of his anatomy. *Ex pede Herculem* has not ceased to be true. It would be impossible for me to adequately treat of all these results in one short hour; the subject must necessarily be deferred to another time and another place. If I have succeeded in showing you that structural features form no insignificant part of anthropology my object is attained.



PAPERS READ.

**EXHIBITION OF DIAGRAMS OF THE BRAINS AND MEDISECTED HEADS OF
MAN AND A CHIMPANZEE.** By Prof. BURT G. WILDER, Ithaca, N. Y.

[ABSTRACT.]

THESE are substantially accurate representations of the objects, having been drawn under the immediate supervision of the writer by an anatomical artist, Mrs. S. H. Gage, from the preparations themselves and from photographs.

The preparations were made from brains alinjected (injected with alcohol) in the craniums; they accord with the writer's suggestion (Vice-president's address on "Educational Museums of Vertebrates," Amer. Assoc. Proc., 1885, p. 280), as to the desirability of comparable dissections of man and apes as a basis for sound discussion respecting the physical distinctions and resemblances between ourselves and our nearest animal relatives.

On the lateral aspect certain principal fissures and gyres are easily recognized in both; but the chimpanzee's prefrontal region is obviously smaller, and there is a less development of the speech center, the sub-frontal gyre ("Broca's convolution"), although its precise constitution cannot yet be determined. The insula, as with most apes and even monkeys, is completely hidden by the lips of the sylvian fissure, although not infrequently somewhat visible in man, as in the mulatto shown in the diagram and even in the philosopher, Chauncey Wright (Ref. Handbook of Medical Sciences, viii, fig. 4779).

The medisected heads are represented as if the line of vision were horizontal; the slight extension of the cerebrum beyond the cerebellum in this young chimpanzee was commented upon by the writer in 1884, in the Proceedings of this Association, p. 524.

The mediconimissure ("middle commissure"), as is usual in mammals, is larger in the chimpanzee than in man, notwithstanding the probability that, as stated by Meynert, the thalami, of which it is the special conjunction, are preëminently large in the human brain.

In general, while the projecting muzzle and the deficient nose and chin readily distinguish the ape's profile, the encephalic resemblances are far more numerous and impressive than the differences; indeed, from the me-

sal aspect of the brain alone, it would hardly be safe to affirm that the one organism is the habitation of an immortal soul and the other among the "beasts that perish;" that the one was made "only a little lower than the angels" and the other "only a little higher than the monkeys."¹

THE EVOLUTION OF A SECT. By ANITA NEWCOMB MCGEE, Washington, D. C.

[ABSTRACT.]

AFTER the Reformation certain sects originated in Germany which protested against the Protestant church just as that had protested against the Roman Catholic church. One of these, the Pietist, was succeeded by the "Inspirationist" sect, which dates from 1714. This was founded by persons who claimed to be inspired; but it made little progress till 1818, when the "Instrument," Christian Metz (afterward aided by Barbara Landmann) came forward as its leader. Under the able guidance of this "inspired" man the believers increased greatly and gathered at one place in the Rhine country. Their distinctive faith was belief in continued inspiration and in the necessity of a pious life. They eschewed ceremonies. Metz, always by means of his inspired messages, led the way to America in 1842, whither the band of believers, persecuted in their German home, soon followed. They settled at Eben-Ezer, near Buffalo, New York. Here Metz found that to maintain the integrity of his sect it was essential to provide for its poor members by having "all things in common," like the early Christian church. This arrangement was consummated in 1846, though with much difficulty. The third great step of the sect was the removal of over 1,000 persons to the then wild country of eastern Iowa, where the villages of Amana were built. This migration occupied the years 1855 to 1865. During later years the community prospered, and now numbers about 1,800 members.

There is here presented the spectacle of a well defined cult, concentrated in one spot, controlling absolutely and in every detail the lives of its adherents and changing little with the lapse of years or the modification of surroundings. Nowhere is there more clearly shown the power of faith and the willingness of the faithful to follow an able leader to the logical and inevitable consequences flowing from the adoption of that faith. In addition to the various points of interest to the student of beliefs presented by the sect, a problem is opened to the psychologist in the strange features of the inspiration received by Metz, Barbara Landmann and their predecessors.

¹ The writer places this phrase in quotation-marks under the impression that it occurs in an article by the late Edwin P. Whipple, "Mr. Hardback on the derivation of man from the monkey."

SUGGESTIONS FOR A PAN-AMERICAN AS PRECURSOR TO A UNIVERSAL LANGUAGE. By R. T. COLBURN, Elizabeth, N. J.

[ABSTRACT.]

I. THE A. A. A. S. has already twice considered the subject of a universal language, and at the Cleveland meeting appointed a committee of three to confer and correspond on the topic. Pending their report and to strengthen their recommendations, it is proposed to show why this Association may properly take the initiative and urge upon the government of the United States (that of Canada coöperating) in proposing an International Congress to adopt, on behalf of American states and such others of Europe and Australasia as may see fit to join, a common and improved tongue.

II. The spread of international telegraphs, cables, mail facilities, travel, shipments of merchandise, nautical codes, standards of time, sidereal and geographic, of coins, weights and measures; the growing identity of technical terms in the sciences and arts and in diplomatic intercourse—all point the way to a uniform tongue. It would be a powerful economic contrivance and a bond of peace tending to mitigate national estrangements. The saving in the mere act of learning to speak and write, in type-setting, translating and the sifting of old and obsolescent learning would be immense.

III. America need not be diffident in heading this movement. The custody of the English language and its amendment are theirs. Great Britain need not be expected to do so; but would, doubtless, with more or less grace, entrust it to the North American scions, after the British A. A. S. had given the cue. It has already done more for the cause of spelling reform than the mother country.

IV. Without entering into details it is easier to say what the new language should not be than what it will be; that is for a Congress to decide. It should not on the merits be founded on the Teutonic or Slav stocks as Volapuk proposes. It should not be so full of irregularities and stumbling blocks as the German, French or English. It should be phonetic, flowing like the Latin, the Spanish and Italian derivations. Above all it should be simple and uniform in its word-building involutions, and symmetrical and scientific in its method.

V. A table is appended (for blackboard) stating approximately the populations employing the English, German and Spanish on the two hemispheres to illustrate the preponderance of the former; its right to a major representation in any joint conference and the justice and courtesy of allowing the Spanish-speaking neighbors their full weight therein. Also that the combined Anglo-Latin peoples would have a majority representation in such a council of the maritime nations on both first and second choice.

THE RELATION OF MIND TO ITS PHYSICAL BASIS. By Prof. E. D. COPE,
Philadelphia, Pa.

[ABSTRACT.]

1. RELATION of sensation to memory.
 Relation of ideation to memory.
 2. Relation of the two to organization and destruction of tissue.
 3. Possibility of control of mind by matter..
 Possibility of control of matter by mind.
 4. Evidence derived from memory.
 5. Evidence derived from judgment.
 6. Result of conclusions as a formula of evolution.
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ON THE ATLATL OR SPEAR-THROWER USED BY THE ANCIENT MEXICANS. By
ZELIA NUTTALL, Peabody Museum, Cambridge, Mass.

[ABSTRACT.]

MY interest in the spear-thrower *per se* was first aroused by Prof. Otis T. Mason's important monograph on the throwing sticks in the National Museum. Dr. Max Uhle's valuable contribution on the spear-throwers of American tribes directed my attention to the existence of the Ancient Mexican atlatl and thus gave the direct incentive to the investigation begun in October, 1887, the results of which I now offer as a sequence to the above publications.

The statements about the atlatl made by the best known modern authorities on Ancient Mexico, such as E. B. Tylor, A. F. Bandelier, H. H. Bancroft, Orozco y Berra, Alfredo Chavero and Dr. Valentini, are scarcely of a nature to encourage research on the subject.

In the old Spanish Chronicles, however, I found a number of scattered notices establishing, beyond a doubt, the general use and important rôle performed by the atlatl at the time of the Conquest.

The next step was to refer to several well-known pictures, contained in the Vatican, Telleriano-Remensis and Aubin Codices, of atlatl, authenticated as such by contemporary texts. Familiarity with these enabled me to recognize an unexpectedly large number of atlatl in other Codices and, what is more important, to identify it as the hitherto unknown weapon held by the sculptured warriors on the so-called Sacrificial Stone of Mexico and on bas-reliefs of Chichen-Itza, Yucatan. These carved representations and the colored pictures in the Codices are so minutely and carefully executed and so clearly reveal both structure and method of use that they fully compensate for lack of detail concerning these points in the Spanish Chronicles. Indirect evidence and finally the Nahuatl text of Sahagun's

invaluable Manuscript *Historia*, which I had occasion to study in Florence this winter, contributed to reveal a complete view of the curious evolution of the spear-thrower in Ancient Mexico.

We seem to see the Indian hunter using it in its simple every-day form to launch the harpoon at the fish and aquatic fowl of his native lagoons or hurl it in savage warfare at his enemy.

In numerous pictures we find it exhibiting elaborate decorations, curious conventional forms, and serving as a mark of chieftainship and priestly rank. We finally recognize ceremonial forms of atlatl in the hands of Aztec deities and in the precious emblem borne aloft in certain religious processions.

The atlatl was in general use, in each of these forms, at the time of the Conquest but soon fell into disuse and became extinct.

To the Aztec mind the origin of the atlatl and spear was by no means shrouded in obscurity but was accounted for by several myths and traditions. One of these is preserved in a Manuscript History written in Mexico in 1576. The second is recorded by Padre Sahagun in his *Historia*, lib. i, cap. xvii. But the use of the spear in warfare was supposed to have been taught by Huitzilopochtli, the hero war-god.

A well-known myth, to which I will revert, relates that he had come to life ready for warfare, "armed with a spear, an atlatl and a shield."

A tradition, as recorded by Torquemada, tells that it was this Indian Mars who incited the Mexicans to battle and had given them the weapons with which they fought, namely, the long spears made of cane stalks and tipped with obsidian, which they threw with a certain implement called "atlatl." It is noteworthy that, in the above traditions absolutely no mention is made of the *maquauitl* or obsidian sword, or of the lance—nor are there any traditions about them. Although these were in general use we are told by the high authority Herrera that "the spear was the weapon most dreaded by the Spaniards." Its use and deadly effect have, in fact, been recorded in at least a few words by each of the following chroniclers: Cortes, Bernal Diaz, the Anonymous Conqueror, Padre Duran, Torquemada, Padre Sahagun, Fray Diego de Landa, Tezozomoc.

With a single exception each of these writers describes or mentions the habitual use of the atlatl with which the spear was thrown.

The Aztec word atlatl or atlatl, as it is sometimes found written, is intimately connected with the verb *tlaçá*=to aim, to throw or cast (Spanish *tirar*), the frequentative of which is *tlatlaçá*.

Considering that the original use of the atlatl was in aquatic chase by the atlacatl or fishermen, whose name is a synthesis of *atl*=water and *tlacatl*=men, I venture the suggestion that the atlatl may primarily have been a synthesis formed with the verbal noun *tlatlaçani*=thrower and *atl*=water. This would give the word *atlatlacani*, meaning "water-thrower," not an unfit name for the harpoon-thrower of the water-men.

However, this is, as I said, a suggestion only, and I refer the question of the exact derivation of "atlatl" to the consideration of Mexican philologists.

Let us now review the scattered testimony I have brought together from the writings of the highest authorities on Ancient Mexico. It proves beyond a doubt that the spear, thrown by a wooden atlatl, was not only in general use at the time of the Conquest, but was acknowledged by the Spaniards to have been the most effectual weapon of the Aztecs.

These, it seems, had only adopted it and acquired proficiency in its use from the time they took up their abode in the Valley of Mexico where they found themselves forced to resort to aquatic chase. Up to that time their chief arm had been the bow and arrow just as at the time of the Conquest it was that of the Chichimecs, of the Mountain Indians and of those tribes that dwelt inland and subsisted chiefly on birds and small game.

Doubtless the Indian tribes inhabiting the coast regions originally used the harpoon for fishing and occasionally in savage warfare, just as the Aztecs did. But this tribe of fierce warriors and conquerors seems to have been the first to create a purely military and a ceremonial form of atlatl.

What the Mexican spear-thrower was like when it had reached its utmost development can best be learnt by examination of its numerous representations in sculpture and in the Codices, the majority of which are contained in Lord Kingsborough's monumental work. For the three specimens of genuine Ancient Mexican atlatl preserved respectively in Rome, Berlin and London, and to which I shall refer more particularly, are comparatively simple and incomplete.

The representations of atlatl contained in the Codices are extremely varied, so much so that there are no two exactly alike even among many taken from the same Codex.

It is a fortunate circumstance, therefore, that when an Aztec artist pictured a warrior or deity with an atlatl in one hand, he generally painted one or more spears, a shield and a banner in the other. These together constituted the complete accoutrements of one grade of war-chiefs. Now it sometimes happened that he omitted one or the other of these; but it is an exceptional case when an atlatl is not accompanied by some other part of military armor.

In cases of doubtful looking atlatl the presence of the spear, as an accessory, may be adopted as a convincing proof of a correct identification. On the other hand, the absence of the spear does not constitute disproof. Indeed had I excluded all atlatl pictured without accessory spears, from my illustrations, I should have been obliged, strange to say, to reject some of the most important representations of atlatl we have; important because of the few whose authenticity is established by the contemporary texts of the Codices containing them.

These described and labelled specimens are in the Vatican (A) and in the Telleriano-Remensis Codices and they prove that a genuine picture of an atlatl is not invariably accompanied by a spear or even by other parts of military armor.

I have endeavored to classify my collection of atlatl and divided them into two classes.

Class I answers to Fray Diego de Landa's description, being usually provided with one or more finger holes at about one-third of its length. It includes :

- 1, atlatl with a single large circular finger hole.
- 1a, ? atlatl with a double hole.
- 2, atlatl with two small holes in the body of the implement.
- 2a, ? atlatl with three holes in the body of the implement.
- 3, atlatl with two lateral rings attached externally; also the three existing specimens of atlatl.

Class II is distinguished by being provided with lateral finger pegs placed exactly opposite each other instead of holes or rings.

Let us take a rapid survey of Class I.

1. In the hands of sculptured warriors.
2. In groups of armor also carved in bas-relief.
3. In the Codices. In this series we can first study the atlatl by itself, then learn by ocular demonstration how the index and middle fingers were inserted into the hole or holes whilst the other fingers and thumb grasped the handle.

We have front views and back views of the hand and inserted fingers holding the atlatl ready for use.

We see it also simply grasped by its handle and finally having its instantaneous though distorted picture in the very act of launching the spear.

We perceive that it sometimes is ornamented with a flat covering of applied feather-work, covered with tiger skin, carved or painted with transverse bars adorned with tufts of feathers, flexible tassel-like appendages or long streamers. We observe that the atlatl itself is generally painted blue while the decoration is of many colors. Having learned all these interesting details from the old manuscripts, let us leave them for a moment and study the three existing specimens of Ancient Mexican atlatl which have come under my notice. The finest of these is in the Museo Kircheriana in Rome where I had the privilege of examining it closely in May, 1890. The British Museum specimen ranks next in excellency of workmanship and is moreover the most complete. It still retains one of the two finger rings made of shell, that were originally attached to its handle. The third specimen is at the Museum für Völkerkunde in Berlin. The three specimens consist alike of a long straight piece of a very hard and fine-grained wood (*zapote?*). Each is provided with a central "spear shaft groove" ending with a "hook or spur" and each must have originally had lateral finger rings, attached like those of the London specimen.

The only representations of atlatl I know of in which the spear-shaft groove and hook are distinctly visible, are those on the bas-reliefs of Chichen Itza. Curiously enough these were overlooked by Stephens and described as "stone knives" by Charnay.

Both of these travellers noted, however, the resemblance of the sculptured figures at Chichen-Itza to those on the bas-relief around the so-called Sacrificial Stone of Mexico. Charnay identified the weapon, represented in each case, as a sacred stone-knife Nebel and Humboldt wrote that the

prisoners on the Sacrificial Stone held "flowers or a branch in their right hand;" Ramirez, Orozco y Berra and Sanchez, besides Charnay viewed the weapon carved on the Sacrificial Stone as a knife. It is, however, undoubtedly an atlatl. It is a significant and most important fact that the identical form of atlatl is found on these widely-separated bas-reliefs, at Chichen-Itza in the City of Mexico. The resemblance coincides, however, with other facts which I will present in a future communication.

Returning now to the pictures of atlatl taken from the Codices, we find that the existence of a "spear" shaft, groove and hook could scarcely be inferred from the front views of atlatl of the same type as the sculptured ones.

But as soon as the artist began to picture the atlatl held ready for use or actually launching the spear he was forcibly reminded of the important rôle performed by the hook. In endeavoring to reproduce this he seems to have sometimes exaggerated its proportionate size. At all events he drew it "en profile" though retaining the back view of the hand and of the finger holes and handle of the atlatl.

This distorted drawing was evidently adopted as one of the conventional ways of picturing an atlatl, and it will be well to bear the possibility of exaggeration and distortion in mind whilst studying all pictures in which the hook is visible. It is, of course, quite impossible for us to judge of the fidelity with which the artist may have drawn the proportions of the hook. The existing specimens and the carved reproductions exhibit a small hook not rising above the level of the sides of the groove. On the other hand we will find a prominent hook pictured in a variety of forms and dimensions and also learn that the large recurvature of one ceremonial form of atlatl caused this to be compared, by the Spaniards, to a bishop's crozier.

Having duly studied the structure and practical side of the atlatl, let us investigate the interesting symbolic and ceremonial forms under which it reappears as part of the paraphernalia of some of the principal Aztec gods.

In the vignettes illustrating the account of Huitzilopochtil's miraculous birth, etc., contained in the Laurentiana MS. of Sahagun's *Historia* (lib. III, cap. 1) we find him depicted with a shield, one or more spears and an atlatl. This is curiously carved in the semblance of a serpent and is provided with lateral finger-pegs (Pl. III, 30, 31). The Nahuatl text relates that it was blue and was named *Xiuatlatl*=blue, or turquoise atlatl.

To find these pictures of Huitzilopochtil with an authenticated and unmistakable atlatl of a blue color, in the shape of a snake, is a fact of no ordinary importance, for it affords a clew to the meaning of the Nahuatl names of his weapons recorded elsewhere in the same MS. It is several times repeated (*op. cit.* lib. I, cap. 1, and *Historia de la Conquista*, cap. 38) that these consisted of a "*xluhcoatl* and a *mamalhuaztli*." Literally translated, *xluhcoatl* means blue or turquoise serpent. *Mamalhuaztli* is, in my opinion, the verbal noun of the verb *mamali*=to cleave, to split, to force one's self into a crowd of people, and means literally: "the splitter, the cleaver," no unfit name for a spear.

Whilst it has been remarked before that the "*xluhcoatl*" was the special symbol of Huitzilopochtil, it has not as yet been recognized that this

"blue serpent" was a name for his atlatl of symbolic form. It is not difficult to imagine why, in the first case, the serpent was selected as an appropriate symbol for the swift thrower of a fatal dart. It is an interesting fact, moreover, that the serpent symbol is prominently carved on each of the existing specimens of Mexican atlatl.

It is still more interesting, however, to ascertain through authentic records that atlatl, made in the shape of a serpent and inlaid with turquoise, were in real ceremonial use at the time of the Conquest.

The serpent atlatl is not, however, exclusively represented with Huitzilopochtli. We find it occasionally pictured as held by Xiuhtecuhtli and Tezcatlipoca. Another ceremonial form of atlatl is invariably encountered in representations of the god Quetzalcoatl. Sahagun describes it as "a sceptre like a bishop's crozier; its top was bent like a bishop's crozier and it was profusely inlaid with mosaic. But it was not as long as a crozier and that part by which it was held looked like a sword-hilt."

Referring first to the pictures of Quetzalcoatl's weapon in Sahagun's MS. (Pl. III, 24 and 25) we recognize in it a recurved atlatl with finger-pegs. Its drawing is evidently distorted; the artist represented, as we have already had occasion to observe in other cases, a side view of the curve and a front view of the handle and finger pegs.

The name for this form of atlatl was "xonecuilli" or "xonoquiltl," and it symbolized lightning and swift destruction.

A third ceremonial atlatl termed "tlachieloni" is usually represented as held by Tezcatlipoca. The term is descriptive, meaning: "that through which one can look," and would be equally applicable to all the atlatl provided with finger holes through which one could look.

Pausing now to review the principal Aztec gods in their representations, one cannot but be struck by the fact established by the foregoing testimony that each god carries, as symbol, some form of atlatl. Turning to the sculptured monuments of Mexico and Yucatan we find the atlatl and the spear and an almost total absence of any other weapon.

The same observation applies to the older Maya and Mexican Codices. In the Mexican MSS. dating from the time of the Conquest one can trace the disappearance of the atlatl by its increasingly incorrect representations and note its extinction by finding these finally superseded by pictures of the bow and arrow. And thus the interrupted evolution of the truly wonderful atlatl, the spear-thrower of ancient Mexico, came to an end.

The atlatl, although exquisitely carved, covered with gold, inlaid with turquoise, decorated with feather work and exhibiting the remarkable degree of skill attained by an industrious and intelligent race, seems indeed to be a fitting epitome of the strange civilization of Ancient Mexico, the real barbarism of which was mitigated by the most marvellous perfection in every detail of industrial art.

[This paper is to be published in full, with illustrations, in the Peabody Museum Papers, Vol. I, No. 8.]

INDIAN ORIGIN OF MAPLE SUGAR. By H. W. HENSHAW, Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

PRESENTS historical and linguistic evidence tending to show that the manufacture of maple sugar is of Indian origin and was taught the Europeans by the Indians.

[Printed in full in the American Anthropologist for October, 1890.]

ARTS OF MODERN SAVAGES FOR INTERPRETING ARCHAEOLOGY. By Prof. Otis T. MASON, National Museum, Washington, D. C.

[ABSTRACT.]

1. STATEMENT of the general proposition.
 2. Caution imposed by changes in aboriginal work brought about by contact with whites.
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FORT ANCIENT. By WARREN K. MOOREHEAD, Xenia, Ohio.

[ABSTRACT.]

OF all the great enclosures erected by the aborigines of the Ohio Valley, Fort Ancient stands preëminent. One or two groups of structures may contain a greater extent of embankment, but in no other instance is there such a display of massiveness, nor would the number of cubic yards of earth in any one of them equal the amount used in the construction of the fortification which it is my purpose to describe. Not in magnitude alone does this enclosure surpass others; the number of implements found upon the village sites, the frequent burial heaps and stone graves, the admirably engineered strategic points, all combine to make it a spot of absorbing interest. In 1847, Messrs. Squier and Davis carefully examined Fort Ancient and published in the first report of the Smithsonian Institution a tolerably accurate map, with quite an extended account of the enclosure. Archæologists who read their description were impressed with the great size of the aboriginal ruin, but no especial interest was manifested until a few years ago when the Bureau of Ethnology of Washington city sent several gentlemen to examine the enclosure and to report upon its condition. Professor Putnam, Dr. Thomas and others interested in the study of prehistoric anthropology have made visits to the Fort and carefully inspected the series of embankments and terraces here exhibited. These several gentlemen, in personal publications and official reports, brought the fortification before the public in such a manner as to draw considerable attention to it and to make it quite a noted place.

As the members of the anthropological section have doubtless frequently seen accounts and descriptions of this structure and are familiar with its outline, my remarks upon the size, measurements and position of the walls will be somewhat condensed. However, for the benefit of those present who have never seen the earthwork, a few statements regarding its position and general characteristics may not be amiss.

Briefly, Fort Ancient is in outline a rude representation of North and South America, with the isthmus corresponding to Central America somewhat lengthened. Situated upon a great plateau, it overlooks upon the west the Little Miami river, while its eastern walls are placed upon a slightly undulating plain. These walls are so massive that, at a distance of two miles, they can be seen distinctly outlined against the sky. On all sides, except along a portion of the eastern side, it is flanked by deep and almost inaccessible ravines. At the highest point its altitude above the Little Miami river is 291 feet. The embankments following the edge of these gullies are very tortuous. Upon the plain the walls are quite straight and are especially massive, as there are no ravines to afford additional protection against assault.

The average height of the walls is 11 feet, the maximum height 23 feet, the minimum 4 feet. Two ravines approaching within 150 feet of each other nearly divide the structure into halves, and for convenience the portion north of these ravines has been denominated the New Fort, while that extension towards the south is called the Old Fort. The isthmus formed by these ravines is about 800 feet in length. Near its centre two crescent-shaped walls extend inwards from the embankments on each side and form a narrow gateway. Four hundred feet south of these crescent walls, at a point where the isthmus is barely sixty feet in width, the Old Fort begins. At this point the ends of the embankment are very high and steep, closely resembling conical mounds—in fact they are so called on most maps.

As the only convenient entrance to the Old Fort is at this point, the name Great Gateway has been adopted to designate it.

The total distance around the summit of the walls is 18,712 feet.

Furthermore, it might be well to add that a large village was once located within the boundaries of the Old Fort, but that no village occupied the site of the New Fort, at least not for any considerable time. This conclusion is reached from an inspection of the ground of each of the forts to a depth of several feet. The isthmus, or Middle Fort, as the space between the crescent walls and the Great Gateway is called, seems to have been the spot most hotly contested in the great battle undoubtedly fought at Fort Ancient; for it is here that most of the human bones, arrowheads and celts are found. No pottery, animal bones, charcoal, broken implements or other wigwam refuse can be found here.

So much for outline and description. The first question that shall engage our attention is: Are there evidences of the presence of more than one people at Fort Ancient? The answer to this query necessitates a long explanation.

The methods of determining whether there was more than one people at this enclosure are a careful examination of the modes of burial and of the various implements and pottery discovered, and an inspection of the crania exhumed from the graves and mounds.

First.—There are two classes of burials observed here. One in stone sepulchres, the other in rude stone heaps.

Second.—There are two distinct varieties of implements found upon the surface.

Third.—There are two varieties of pottery, the one being plain, the other of superior material and covered with rude decorations.

Fourth.—We find skulls of two distinct forms—the dolichocephalic, or those relatively long from the frontal to the occipital bone, and the brachycephalic, or those having the two diameters more nearly equal. In the course of his explorations Professor Putnam has found these evidences of the long-headed and the short-headed peoples in various parts of the Ohio Valley.

The neatly constructed stone graves or sepulchres are found only in the Old Fort and in the cemetery bordering upon the Little Miami river. The stone mounds, or heaps of stone are found upon all the prominent points of land and upon the terraces which in many places follow around the hillsides of Fort Ancient. Each of these consists of from ten to twenty wagon loads of small and irregular limestone slabs. The bodies over which they were placed seemed to have been hastily dragged together, and in no instance do we find any order of burial observed, such as is noticeable in stone sepulchres.

So far as I am aware there has never been a skeleton taken from the earth-mounds within the structure. There are seven small mounds rather low and flat in the immediate neighborhood of Fort Ancient, but these when opened yielded nothing whatever that would indicate their construction for burial purposes. They may have served as stations or foundations for houses or other structures, as in them we discovered broken flint implements, pottery fragments, animal bones and charcoal. Skeletons have been found in the Fort walls themselves, but instances of this nature are quite rare and seem to be due to subsequent intrusive burials.

In the stone graves the body was placed three or four feet from the surface, and walled in on each side as well as at the head and feet, with large, flat, limestone slabs from the creeks and hillsides adjacent, while the largest stones were used as covering; thus, many of the interments almost excluded water on account of the exactness with which the slabs were fitted to each other. Many of these stones were four feet in length and weighed upwards of one hundred pounds. Generally the grave was seven and one-half feet in length, with a breadth of two feet to thirty inches, and a depth of eighteen to twenty-four inches.

It is almost impossible to save entire the crania found in the stone heaps, as the stones rest immediately upon the skeletons; but we have been able to restore many of them from their fragments, and these, together with several only slightly injured, have furnished us with a sufficient number

to note the difference between them and the crania from the stone graves. The latter secured the better preservation of the bones, and therefore, nearly fifty crania in various stages of perfection have been obtained for our study and examination.

The Little Miami river, flowing towards the south, courses through a valley about a mile in length and half a mile in width. This valley is shut in by high hills and forms an admirable location for a village site, for which purpose it was used for a long period of time by one race of people. For a distance of four hundred yards back from the river, and extending from the hotel and store of the town Fort Ancient, up the river for a quarter of a mile, the ground is intermingled to a depth of five and one-half feet with matter which accumulated from wigwams or lodges long situated in this area. One peculiarity of this village site is that stone graves in large numbers are found on its eastern limit and these graves contain the bodies of women and children. No adult male skeletons have been found in this cemetery. The village seems to have been occupied at three different periods and beyond question each period of occupancy lasted for many years. Five and one-half feet below the present surface we find here and there a bed of ashes or a mass of burnt rock, around which and in which occur large numbers of mussel shells, many of them perforated, shells of the land tortoise, pottery fragments, flint chips, stones used for hammering, etc. There are about two feet of earth, which the river may have deposited by freshets in a comparatively short time, or which may have slowly accumulated during a period of one hundred or more years that the ground was unoccupied. Above this is a second layer of refuse, much heavier than the first, while the third or upper stratum is but one foot from the present surface. The following list of objects from a space of one yard square, will give an idea of the number of implements and bones found at the spot:—

118 bones of fish, 117 fragments of pottery, 17 bones of the common deer, 4 bear bones, 7 turtle shells, 7 arrowheads, 4 hammer stones, 82 mussel shells, 4 wolf bones, 2 broken celts, 7 rabbit bones, 5 bone awls, 200 small unidentified bones split lengthwise, 6 large flint scrapers.

The preservation of these minute bones and fragile shells is due entirely to the ashes in which they are embedded. Many fires, continued for a long period, left thousands of bushels of fine wood ashes; which, having a wonderful preserving power, have secured through a lapse of centuries perishable objects for our study.

That there were two races contending for the earthwork, is also suggested by the following facts:—

First.—In a field within half a mile of the New Fort, upon a knoll commanding a splendid view of the enclosure, is a small area upon which were manufactured arrowheads, many of them being made of crystallized quartz. This material is foreign to Ohio, except in specimens too small to be used in making aboriginal weapons; therefore, its presence proves conclusively that a distant tribe was present when these chippings were deposited. It may be asked, "Was not this quartz obtained by trade?" But if it had

been used by the people stationed within Fort Ancient, why did they not work it into form upon their own village site, in the same spots where we find evidences that they manufactured chipped implements from several varieties of flint, including much of the kind found only in Licking county, Ohio?

Second.—Upon the village site in the Old Fort, and upon that near the Little Miami river, we find thousands and thousands of pottery fragments, some of them exquisitely decorated and evincing the same idea in ornamentation and art that Dr. Metz has noted at Madisonville. In the bottom of the ditches outside the Fort and in the fields bordering it upon the east side, we find a class of pottery sherds entirely different from those found within the structure. In support of this statement I have upwards of five thousand specimens of the two varieties.

The pottery of different tribes of aborigines is often characterized by some peculiarity of decoration or method of manufacture. The Arkansas and Missouri pottery can be distinguished by experts from that found in Tennessee, while the Georgia pottery does not look like that from Florida, nor do the Virginia and Maryland fragments in any way resemble those found upon the Iroquois village sites in New York; therefore, I have but to call the attention of the gentlemen present to the specimens of pottery here exhibited, and leave to their judgment the decision of this question.

There arise for consideration many questions, all important and deserving of discussion; but time and space will permit the mention of only a few. For instance, the age of Fort Ancient; the purpose of the terraces; the age of timber upon the walls, or of ravines which have formed in tough glacial clay since the structure was erected. Years might be spent at Fort Ancient in careful excavation of the graves that exist in such numbers beneath the sombre shadow of towering oaks and beeches, and yet there would remain sufficient material to engage the attention of antiquarians for a long time to come.

This great inclosure, so rich in facts, so productive of implements that tell us of the every-day life of the ancient people who lived within its walls, may reveal to the patient investigator a history that shall go far towards dispelling the darkness that surrounds the origin and movements of ancient man upon the American continent.

Finally, as archæologists all over the United States were rejoiced to hear three years ago, that, through the efforts of Professor Putnam, the Serpent Mound was bought and preserved in a public park through the generosity of the ladies of Boston, so they will rejoice again with those who through the long, hot summer of '89 toiled and labored at Fort Ancient, when they hear that the state of Ohio has at last made an effort looking to the purchase and preservation of this grand fortification as a state park. Thus we hope that it will be secured from the destroying plow of the farmer, and the careless spade of the collector, for the edification and study of future scientists of the United States. It is sincerely to be hoped that the day is not far distant when every aboriginal structure in this country shall become the property either of the government or of institutions competent and able to explore and preserve them.

NOTICE OF A SINGULAR PREHISTORIC STRUCTURE AT FOSTER'S, LITTLE MIAMI VALLEY, OHIO. By Prof. F. W. PUTNAM, Cambridge, Mass.

[ABSTRACT.]

AN account of the explorations, now in progress for the Peabody Museum, of an ancient work, principally on the land of Messrs. Clarke and Schimmel, at Foster's, Ohio. A ridge of burnt clay and cinders, faced on the outside with stones, extends around the sides of a hill, cutting across the level field on the southeast and north between the Little Miami river and Munger's creek. This ridge is in places eight to ten feet high and in other portions forms the hillside to an equal depth, and is about fifty feet in width. The total length of this burnt and artificial ridge is two thousand eight hundred and forty-three feet. In several places, where the examinations have been made, the external wall was found to have been carefully made of pieces of limestone, and several interesting structures of stones were found in a projecting northerly portion of the work. The great amount of heat necessary to produce such burning of clay and stones, and such masses of cinders as were found in the sections made, is remarkable, and why and how this was done is not yet discovered. The explorations are still being carried on under the immediate charge of Mr. Hillborn T. Cresson and Mr. George A. Dorsey, of the Peabody Museum, whom I have left in charge. A plan of the work made by Mr. Cowen, sketches by Mr. Cresson and photographs by Mr. Saville, showing the results of the work already accomplished, were exhibited to the section.

ON ANCIENT HEARTHS IN THE LITTLE MIAMI VALLEY. By Prof. F. W. PUTNAM, Cambridge, Mass.

[ABSTRACT.]

DURING our explorations of the Little Miami Valley, Ohio, several ancient hearths have been found from time to time. These hearths were first discovered by Dr. C. L. Metz, who several years ago called my attention to them. Since then he has directed the attention of the Peabody Museum parties in the field to such exposures upon the river banks as they are washed away by floods. During the month of July last five hearths were found on the north bank of the river about half a mile below the entrance of the East Fork, in Anderson Township, Hamilton Co., during the examination of the banks by H. T. Cresson and Ernest Volk, two field assistants of the Peabody Museum, who for several weeks were specially engaged in making an examination of the gravels and the river banks of the valley.

The lowest of these hearths was found by Mr. Cresson and is thirteen feet below the surface of the bottom land.

This hearth is made of flat, glacial pebbles picked up from the river bed, where they had been deposited by the river cutting its way through the moraine about one-quarter of a mile above. The hearth is nearly ten feet long and of considerable width, but the latter can not be determined as part has been washed away and the remaining portion is still buried in the bank, as seen in the photograph exhibited. We have first the present river bottom of gravel and pebbles, then a stratum of coarse gravel, finer above and mixed with silt. On this rest the burnt stones forming the hearth, showing that at that time this was the surface of the bottom land. On these burnt stones were ashes and charcoal. Over the hearth are three feet of fine silt, showing a deposit made in still water and over this a narrow stratum of fine gravel, showing that a swift current existed for a time; then follows the fine silt of quiet water deposit to the present surface. These several hearths give evidence of alternating changes in the filling up of this great valley to a height of twenty feet or more above the present channel of the river.

**PRELIMINARY STEPS TO AN ARCHAEOLOGICAL MAP OF FRANKLIN CO., IND.
By HARRY M. STOOPS, Brookville, Ind.**

[ABSTRACT.]

FRANKLIN COUNTY is situated in southeastern Indiana, bordering on the state of Ohio.

It is drained by the White Water river, which was a favorite resort for the early people of America as is evidenced by the remains which they left along the banks of the streams, and on all prominent points of projecting hills. The mounds that contain the most remains are those on the hills and highest river terraces. One mound, known as the Glidewell mound, contained as many as twenty skeletons with bracelets of copper and stone implements of all kinds.

Others contained only a few fragments of burnt bones and charcoal.

Others are made up of clay which is burnt as hard as fire brick.

On the points of the hills, which command a fine view up and down the valley, are stone mounds. These mounds are made of stones of various sizes, loosely heaped together. Some of these mounds are not more than one foot high while others are five or six feet in height.

In these mounds are found human bones in small fragments. The bones of the wolf and fox have also been identified. These mounds can be seen one from the other, and are generally on the highest hills.

One of these mounds, in the earliest recollections of the first white inhabitants, was of an oval shape, built of loose stone, and was five or six feet high with a confused mass of bones heaped together within the heap.

ABORIGINAL STONE IMPLEMENTS OF THE POTOMAC VALLEY. By W. H. HOLMES, Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

ABORIGINAL stone implements of the Potomac region are in the main of ordinary varieties and are probably the handiwork of Algonkian peoples.

Three native varieties of stone were extensively used, soapstone, quartz and quartzite. Quarrying was very generally resorted to in securing the raw material; the methods of quarrying are found to vary with variations in the material and in the conditions under which it exists.

The steatite quarries were worked to secure material for vessel making. The implements used in quarrying and manufacture are of equal interest with the real products of the quarries and of their associated shops.

Quartz and quartzite were employed chiefly in the manufacture of spear-points, arrowpoints and presumably of knives. The materials were mainly in the form of boulders which were quarried from the bluffs; they were shaped by percussion. The products of the quarries and of the associated shops were leaf-shaped blades, which are believed to have been carried away to be subsequently reduced to final shapes. Millions of failures and broken pieces were left upon the sites and these being rude have been mistaken for paleolithic implements.

In cases where a village was located upon a site which furnished the raw material for implement making, all the stages of progress are represented in the refuse; the roughing out and finishing of the implements were accomplished on the one site and the relics plainly indicate this.

In cases where the villages were upon sites not supplied with quartz and quartzite we find no rude forms, but only the blades carried there from the quarries together with the more highly elaborated or fully finished tools made from these blades.

That the rude forms of chipped stones are not tools at all is proved by their having been left upon the quarry and shop sites. That the blades produced were Indian work is sufficiently proved by their occurrence upon all Indian village sites and their constant association with Indian relics.

FORM OF THE HUMAN EAR. By Prof. H. D. GARRISON, Chicago, Ill.

[ABSTRACT.]

THE writer believes that the crumpled and crushed down form of the external ear in men and the higher monkeys is due to the habit of lying on the side of the head and therefore on the ear; and that this habit was acquired and is still maintained, to accommodate the large and ever increasing mass of brain. This deformity repeated for countless generations has become congenital.

EXHIBITION OF A BONE IMAGE FROM LIVINGSTON CO., N.Y. By Dr. CHARLES C. ABBOTT, Univ. of Penn., Philadelphia, Pa.

EXHIBITION OF GOLD BEADS OF INDIAN MANUFACTURE FROM FLORIDA, AND OF ONE FROM NEW JERSEY. By Dr. CHARLES C. ABBOTT, Univ. of Penn., Philadelphia, Pa.

OBSIDIAN IMPLEMENTS OF CALIFORNIA. By H. N. RUST, Colton, Cal.

THE BASKET-MORTAR OF SOUTHERN CALIFORNIA. By H. N. RUST, Colton, Cal.

THE ADZE IN CALIFORNIA. By H. N. RUST, Colton, Cal.

REMARKS UPON THE MOUNDS OF SULLIVAN COUNTY, INDIANA. By JOHN W. SPENCER, Paxton, Ind.

A STUDY IN MENTAL STATISTICS. By Prof. JOSEPH JASTROW, Madison, Wis.

DAILECTIC STUDIES IN THE SWEDISH PROVINCE OF DALECARLIA. By J. MÜLLER, M.D., Upsala, Sweden.

PECULIAR EFFECTS OF THE OCCUPATION OF MAN UPON HIS ANATOMY AND PHYSIOLOGY. By J. MÜLLER, M.D., Upsala, Sweden.

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ADDRESS
BY
J. RICHARDS DODGE,
VICE-PRESIDENT, SECTION I.

THE STANDARD OF LIVING IN THE UNITED STATES.

I.

In discussing the standard of living in the United States of America, I shall consider the producing classes as the people. They constitute the great majority, embody the vital forces of the nation, and represent its life and distinctive character. Those who eat the bread of idleness are much alike in all countries, doing little in illustrating the genius of institutions, and less if possible in material development. While basing conclusions upon a comprehensive study of national and international statistics and personal observation of life in many countries, I shall not go into statistical details and minutiae of evidence from which these deductions are drawn.

CONDITIONS FAVORING A HIGH PLANE OF LIVING.

An analysis of the conditions which mould the life of the people representing the civilization of the world leaves no room for doubt that the American standard of living is the highest known. The barrier of primogeniture, the repression of caste, the compulsion of social distinctions are obstructions in the path of ambition which have no existence here. In the nations of Europe most advanced in freedom there are still little chains of mediævalism which fetter the action and repress the spirit of the citizen. It is difficult there to cross the boundary of ancestral vocation, and still harder to rise in the social scale. Deference to superior station degenerates

into servility in the subordinate official, while humility in the servant falls into flunkism. The conscriptive clutch of arbitrary military rule holds in its iron vice the youth and manhood of European nations, and drives the enterprising and ambitious into exile. How often has the American in foreign countries noted the chafing under these social and industrial fetters, and the flush of shame which tells of aroused and baffled ambitions.

In this country there are no barriers to wealth or station which capacity and persistence cannot sweep away. It is the rule, and not the exception, that the chief magistrate has arisen from the scenes of humble life. The career most inconspicuous in the beginning has had the most exalted and honorable culmination. The influence of such examples would suffice to stimulate the ambition of the humblest, were it not that they are an effect rather than a cause, the result of the atmosphere of independence and elevation which surrounds the masses, which acts with more promptness and potency than the ultimate persuasion of a brilliant example.

Physical influences are here in harmony with the intellectual. The western world, in its most temperate zone, with long reaches towards the tropics and approaches towards the North pole, with a breadth bordered by the two great oceans of the world, and spanning practically the possibilities of climate by altitude, is in extraordinary measure independent of other lands. It is a new world, though geologically old; rich in soils, in woods and waters, minerals and metals. These resources invite development; and social and political freedom stimulate noblest daring and highest enterprise in their utilization. Labor has an incentive, enterprise a motive, and skill a phenomenal growth. Wealth results; and whatever the grasping tendency of human selfishness, which seeks an undue share of proceeds for direction or for use of capital, labor demands and secures a larger share than in other countries, because it is not only more intelligent but more self-respecting and self-asserting.

The laborer stands on a relatively elevated plane. If native born, he has no conception of the limitations by which the life of his brother in other civilized countries is restricted, and would not tolerate them for a moment. He requires more and better house room, food in larger quantity and greater variety, clothing for his family, books and facilities of education for his children, and something for social life, amusements, and even charities. He is apt to be interested in politics, in social or beneficiary or religious organizations,

and oftentimes in all of these. I would not aver that his foreign brother does not possess similar tastes and preferences, but hold that his exercise and enjoyment of them are in more restricted measure, under the limitations of purse and social usages. It is true that the range of individual living is broad in every country ; it is only the mean, the average mode of life, that is here considered.

Want is not unknown here ; the poor and afflicted are everywhere. Yet in large districts in the United States almshouses are unknown, and the poor are too proud for alms. In the older and denser settlements the dependent classes are few in comparison with those of any country in Europe.

A comparison with the most favored foreign country will suffice. The Tenth Census returned 66,203 paupers, or 1.32 to every thousand of the population. The record of 1850 was 50,353, or 2.17 to every thousand. This shows a gratifying decrease in pauperism in a period remarkable for increase of national wealth. In England and Wales the number of paupers in 1873 receiving relief in the several Unions and Parishes under Boards of Guardians was 887,345, and in 1888 the number was 825,509. The returns do not quite cover the entire population, which was 28,628,804 in 1888, but assuming that they cover all of England and Wales, the number would be 28.8 for every thousand people. This is in violent contrast to the situation in this country. Twenty-two to one is a paralyzing difference, illustrating the relative status of living of the working classes of the two countries.

COMPARATIVE FOOD CONSUMPTION.

In the use of food our people are profuse and even wasteful. All classes use meats freely, ordinarily three times daily. A great variety of fish, oysters that have a fame extending beyond seas, and various forms of the crustacea enrich the national dietary. According to accepted statistics, Great Britain consumes an average meat ration not over two-thirds as large as the American, France scarcely half as large, Germany, Austria and Italy still less. The more favored and fortunately conditioned laborer of continental Europe gets meat on Sunday, and two or three times during the week, yet the statement of one of our consuls in Germany that "the working man rarely eats meat, except in form of sausage, and his wife and children scarcely know the taste of it," is fairly represen-

tative of large districts of many countries. Another, writing from Italy, refers to laborers as "living on what our workmen would despise."

A large proportion of the meat used by the peasantry and other continental laborers is in the form of soups, to give a flavor and suggestion of fatness to the vegetables which constitute the substance and nutrition of the daily diet. The water in which our meats and vegetables are boiled, which is sent to the sewer, would suffice as the basis of palatable and nutritious food for millions of Europeans. If solid food is preferred to liquid, it may be had in Italy and elsewhere; a "thick porridge, made of vegetables, flour and corn meal, boiled in water, an adhesive mass of the consistency of clay, cut with a wire like soap."

The laborer's dietary is improving in these countries. It has already greatly improved in England. Mr. Giffen, the statistician of a government department, the Board of Trade, in noting the advance, admits that "meat fifty years ago was not an article in the workingman's diet as it has become since. He had little more concern with its price than with the price of diamonds." Carlyle, perhaps inclined to be cynical and extreme, speaks of the workman's home, "over which malaria hovered," with a frame subdued by toil and "never sustained by animal food," that when drenched by the tempest could not change its dripping rags, and was "indebted for its scanty fuel to the windfall of the woods." Thornton forty years ago said of the diet of the Dorsetshire laborer, that "bread and potatoes form the staple of their food, and they scarcely know the taste of meat." Now meat is quite generally used, yet sparingly in many districts, in the form of bacon as a relish and a flavoring of vegetables, and in the solid mutton fat of the heavy English breeds of sheep, of which a pound or two will go so far in imparting a meat flavor to cereal or vegetable foods. It is certain that many a family in England, of the class of farm laborers, habitually consumes less meat than an average "farm hand" in this country. And the English farm laborer as far surpasses his continental brother, in the use of meat, as he falls behind the usage of his American confrère. Yet the condition of the English laborer is greatly advanced, and his food consumption large in comparison with that of continental laborers.

The American negro, even in the days of slavery, was usually allowed a weekly ration of 3 pounds of bacon and a peck of meal,

besides vegetables and other products either of the plantation or his own garden patch. This made at least 150 pounds per annum, not to mention the occasional opossum and chicken that were respectively his legitimate game and his illegitimate plunder ; and this amount of meat is more than the average consumption of any European nation, and two or three times as much as the average ration of several of them, including with the peasant and artisan the citizen and nobility.

The average consumption of meat in the United States is probably not less than 175 pounds per annum. Of other civilized nations, only Great Britain exceeds 100, and many of them scarcely average 50 pounds. The consumption of the cereals, by man and beast, is three times as much, in proportion to population, as in Europe. For the past ten years the average has been forty-five bushels for each unit of population, while the usual European consumption does not vary greatly from sixteen bushels per annum. While all is not used as food for man, no small part of it contributes to the meat supply.

The average consumption of wheat for bread is nearly five bushels, and about three bushels of maize and one bushel of oats and rye, or approximately nine bushels for each inhabitant. The average European consumption of wheat is about 3.5 bushels. In the consumption of fruits, the difference between this and other countries is marked with unusual emphasis. Small fruits, orchard fruits of all kinds, and tropical fruits, as well as melons of many varieties, are in profuse and universal daily use in cities and towns, and in the country the kinds locally cultivated are still cheaper and more abundant in their respective localities, though scarce in the regions of recent settlement and those unsuited to a wide range of species.

The consumption of vegetables is not excessive. The products that are rarest and dearest are those which are advancing in relative prominence in the dietary of the people. Variety and quality in food products are the points in which progress has been continuous and extensive. Not unfrequently skilled mechanics or miners, making high wages, are more fastidious and profuse in their marketing than citizens living upon the profits of capital. The abundance and variety of every form of food production, and the general distribution of means for procuring it lead to profusion and tend to wastefulness.

THE CLOTHING SUPPLY.

The American people are no less profuse in clothing than in food. This country is a favored land in fibre production. More than four hundred millions of dollars is the comfortable sum which represents the present fibre products, in the form of cotton, wool, hemp and flax. There is also experimental production of silk, ramie, sisal, jute and many others suited to the climate, some of which will ultimately become the foundation of industries.

More than half of the material for the cotton factories of the world is grown here, and a third of that is manufactured and mostly consumed at home. If 65,000,000 people require one-sixth of the cotton manufactured in Europe and America for the use of nearly 450,000,000 inhabitants of these continents, and of the millions in India, China, Japan and other countries obtaining supplies from the factories of Christendom, the disparity in consumption between this and other countries must be great indeed.

With an average *per capita* consumption of 17.5 pounds of cotton, 8.5 of wool, and a large quantity of silk, linen and other fibres, the claim of superiority in supply of clothing cannot well be disputed. Thus one-twentieth of the population of the world consumes nearly a fourth of the wool product of the world. If the people of Europe should demand an equally liberal supply the earth might be scoured in vain for the requirements of such a consumption. As they do not, it may be supposed that a larger proportion of cotton would be needed; but a consumption equal to that of this country would not leave a pound for North or South America, Asia, Australasia or Oceanica.¹ Indeed it would not suffice for more than a supply of 15 pounds per head to Europe alone.

OUR HOMES AND THEIR ADORNMENTS.

The satisfaction of dietetic and sartorial demands of our people is no more imperative than the urgency of their requirements for home-making and ornamentation. No able-bodied craftsman or skilled laborer, at forty years of age, needs to pay rent for his hab-

¹ Ellison in his "Cotton Trade," makes the average weight of cotton goods consumed annually 5.68 per head. Belgium uses 9.8 pounds, Great Britain, 7.56, Germany, 7.53, Austria, 5.27, Italy, 5.06, Russia, 3.31, etc.

itation from inevitable necessity. If he does, it is because of extravagance, mismanagement, dissipation, or peculiar misfortune.

There are crowded and unhealthful quarters in New York and other cities, but they are mainly occupied by lower classes of foreigners. Philadelphia, a city of the largest class, with a million of people by no means exclusively native born, has a dwelling house for every six inhabitants. Washington is equally well provided with homes largely owned by their occupants. Not a few of the colored residents of the Capital City own houses in which they live. Every town, village and hamlet is filled with homes built or purchased by those who occupy them.

There are log cabins in the South, board dwellings on the prairies, and even "dug outs" on the plains of the more distant West; but they are temporary expedients of those too busy in opening farms and growing crops to build permanent houses, and too poor to use their scanty capital in expenditures not immediately and largely productive. If at the end of a few years the settler still occupies such quarters, one may well question his industry or his sobriety.

A glance at the census records of manufacture of furniture and furnishing, of hardware, of heating and illuminating apparatus, of ingenious devices for saving labor and expediting domestic processes, reveals a wealth of suggestion in the lines of comfort and of luxury in building and ornamentation of homes. The fact is gratifying as it is indisputable, that a large part of this material goes into the houses of the working classes; if not so much of the costly and elegant, at least a large proportion of the tasteful, ingenious and comfortable appliances of home equipment and adornment. There is many a mechanic who runs his wires and places his battery for electric bells in his modest cottage; or his minor son at school may do it for his amusement and as an experiment in science and mechanism.

It is the rule, not an exception, that a large proportion of the masters of industry, whose homes are the most spacious and elegant in their neighborhoods, have risen from comparative poverty, from the industrial ranks, through opportunity, energy and persistence. In every class of workers from the skilled artisan to the laborer, those who unite industry and economy secure homes, and in many cases acquire a comfortable competence.

The evidences of prosperity of the producing classes are not seen alone in well furnished homes, but in many forms of profitable in-

vestment, in real estate, stocks and bonds, and in money in savings banks. There has been much talk of decline of population, of deserted farms, in some of the Eastern States, notably in New Hampshire. Yet the Census shows there a gain of about thirty thousand, or nine per cent, since 1880; and there are nearly twice as many depositors in savings banks as there are families. Indeed, these deposits represent a sum nearly ten times as much as the *per capita* share of the people of that State in the national debt, and are many fold more than the share per head of the people of Great Britain in their savings bank deposits. Volumes of facts illustrating the prosperity of our working people might be adduced, were the truth not patent and clear to every intelligent observer.

EDUCATIONAL AND AESTHETIC CONSIDERATIONS.

The American citizen is not content to exist as a mere animal. Physical well being does not limit his desire or aspiration. He feels that he possesses a mind and a soul as well as a body, and recognizes the necessity of culture. He has ambition to rise in the social scale, through merit and progress, though he has an open contempt for distinctions founded on pretence and gilded demerit. He is especially solicitous for the welfare and advancement of his children, and freely depletes a limited income in their education and training for a career in life, often upon other than ancestral lines. This tendency may become excessive, and has already to some extent, as it must be admitted, in creating a distaste for useful industry and a desire for conspicuous position, for accumulation without labor, and speculative rather than productive occupation. The disposition to avoid work, and live upon the proceeds of the labor of others, is quite too general among all classes of young people, not excepting the colored race. It is a tendency that is the natural result of the acquisition of fortunes as if by magic, but it must be combatted with energy, in the interest of legitimate industry, free government and good morals.

Thus the average American lives upon a high plane, exciting the envy or the emulation of people of other countries, and inducing extraordinary immigration. This popular wave, in its movement during the last decade, represents a population as large as that of the neighboring Dominion of Canada. It is ten per cent of our own population in 1880. It is equal to that of more than one European country. This continuous living stream, flowing to America

from all countries of the world, attests daily the superior elevation of the American standard of living.

HIGH RATE OF AMERICAN WAGES.

A high standard of living, as indicated in the larger consumption of food and clothing, and a superiority in habitations and their furnishing, and in other expenditures of the average American, requires higher wages. While the wages of European artisans and mechanics, and of farm laborers have advanced in recent times, they nowhere approach very closely the rate of wages received by the same classes in this country. In an extended discussion of the rate of wages, in the leading occupations, before the London Statistical Society, in 1880, by Mr. J. S. Jeans, it was claimed as a deduction from available statistics that the wages in the United States were 205 per cent higher than in France, 162 per cent higher than in Germany, and 84 per cent higher than in Great Britain. His estimate of the agricultural wages of Great Britain was 12s. per week, or about \$150 per annum. The average wages of white farm laborers in the United States, as returned to the Department of Agriculture in May of the present year, is \$276 per annum, which is 80 per cent above the rate quoted for Great Britain.

According to accepted estimates of the rate of wages of men in the principal trades of France, the wages of women in this country are from 60 to 80 per cent higher. A report of the Department of Labor makes the income of women from regular occupations, as averaged from 5,716 returns in 22 principal cities, \$295.54 per annum, with \$40 average additional income in 682 of the returns.

A large mass of detail could be given, showing a wide range of differences in the rates of labor of this and other countries, in the various occupations. It would not be easy to make exact averages, but a glance only is requisite to show the great disparity between wages in the United States and any other country that might be named for comparison.

No patriot or humanitarian desires to see a material reduction of the rates of wages in the United States. It means inevitably a lowering of the standard of living, a hindrance to home-making, a delay in the payment of the mortgage that in some instances helped to build a home, and a debasement of the spirit of independence that is the glory of the American citizen.

THE STATUS OF OUR FARMERS.

Land is the freest thing in America. The original cost of the fee simple of our lands is less than the rental of farms in most European countries. The "public land area," three-fourths as much as the area of all the countries of Europe, is carved into free farms for native born and emigrant alike. All who would cultivate the soil, and enjoy a home in the country, can have the opportunity if they have energy and inclination to select and improve the farms they seek.

With nine million farmers and farm laborers, cultivating over five million farms, but a third of the land is taken up, but a small part of that is under crops, and the area under nominal cultivation is superficially treated and scarcely up to half its maximum production. There is nothing surprising in this. Cultivation is always primitive where land is cheap, before land speculation gives place to scientific agriculture. For this reason the richest lands are often found to give the lowest yields; for this reason the average wheat yields of the prairies of Iowa are less per acre than those of the granite hills of the East.

Very few countries of the world have any surplus of agricultural products. None surpasses the United States in the proportion of such surplus. One-tenth of all the products of agriculture are sent to foreign countries to supply their deficiencies. Cotton is almost a monopoly, tobacco a native product of peculiar adaptation to our soils, and the production of maize represents three-fourths of that of the world. Our climates and soils, in the growth of these commodities, manifestly handicap the competition of the remainder of the world. It is an immense advantage that inures to the benefit of our cultivators.

During the past ten years the home market for the products of agriculture has increased thirty per cent from advance of population alone. In three or four decades the wants of sixty-five millions more will double the present demand upon our agriculture, and make a market for products ample for subsistence of more than a hundred millions of European people. Great Britain, in her little garden patch largely occupied by houses and pleasure grounds, produces half a supply; the sea sands of the Netherlands partially feed a dense population; eastern Europe is an enlarging granary;

and the western nations usually supply their food requirements; therefore there is little prospect in the immediate or distant future that our foreign market will be worthy of consideration in comparison with the present overwhelming and constantly augmenting importance of the domestic market, which is the hope of the farmer of the future.

If one will visit the farms of Ohio, which fifty to seventy years ago cost one to two dollars per acre, he will find them valued at \$40, \$60, \$75 or more per acre, with commodious and substantial farm buildings, and not a few with elegant furniture, fine carpets, pianos and libraries. There are many less pretentious and more humble dwellings, but the improvement has been rapid and general, even universal. Farther west, across the Mississippi, the Missouri, to western Nebraska, advance in settlement, in buildings, implements, stock and value of lands, has been rapid and striding, in proportion to length of time and facilities for development.

The social and educational facilities required by our farmers, the expense of house furnishing and adornment, the equipment in horses and carriages and other comforts of life, were never dreamed of by their parents, and are such as are not now unattainable in cities except by those whose respective incomes are told by thousands of dollars per annum. In the newer settlements, in distant states, there are multitudes of humbler aspirations and more limited means of gratification; but everywhere, except in the most unprogressive regions, the style of living has advanced immeasurably beyond the status of thirty years ago. It is a matter of frequent and universal comment, coming within the observation of every person of middle age.

Within a few months past there has been an expression of dissatisfaction with the profits of farming, made mostly by political farmers, and relating mainly to the prices of cereals. Cotton brings fully the average price of the last decade, and the last crop was the largest ever grown; still the ferment of dissatisfaction has leavened the whole south. State and national statistics of the last ten years show that agricultural indebtedness has decreased in that region, that the home market is increasing, and that prosperity is more general than ever before; still farmers appear to be unhappy. It is mainly a case of aroused ambition, and a determination to be felt in business, and especially in politics—and it is in these respects a hopeful indication.

There is more show of depression in the far west, and it is due

to over settlement, the purchase of arid railroad lands at too high a price, to dry seasons, and to an unwise persistence in over production of cereals and neglect of other forms of production for which there is a better market. The farmers of this region grow a million acres of flax for seed and throw away the straw from which fibre can be made worth one hundred dollars per ton ; and then cry for free sisal fibre for binding twine, when they could grow hemp and have a better quality manufactured at home, and save the millions that are sent to foreign countries. The beet sugar enterprise of Kansas and Nebraska, it is hoped, will soon open the eyes of the frontier farmers to the folly of refusing to diversify their production and relieve any depression caused by failure to produce the products for which we pay hundreds of millions in gold and silver to foreigners.

There has been much said about farm mortgages,—quite too much. The most reckless exaggerations have been made, and unfortunately have been repeated in legislative halls, and in newspaper interviews and editorials. If the census can obtain the facts, it will show that they have been magnified enormously to mislead the public. All statistical analysis of available data testifies to the truth of this averment. Much the largest proportion of the farm mortgages of the country are for lands and improvements, increase of investment, settlement of estates, and release to sons by wealthy retiring farmers, and are evidences of enterprise and self-reliance and thrift. In arid lands west of the Missouri there have been crop failures, which have proved disastrous. Thousands without means have gone to the verge of settlement, and risked everything upon the uncertainties of the season, in the hope of building a home which shall be a future competence or lead to a gainful sale. This is not farming ; it is land speculation, with all its risks.

The future of the farmer of America depends upon himself. His position is high above that of the cultivator of Europe, and his prospects brighter. If he studies his interest, looking beyond the present to the practical possibilities of the future, and in politics follows statesmen rather than demagogues, he will continue to prosper.

II.

SHALL THE STANDARD OF LIVING BE MAINTAINED?

This is a grave question. Upon its maintenance depend the future education, enterprise, independence and prosperity of the peo-

ple. It is pertinent also to frame the inquiry, will it be maintained? for there are influences, from without and perhaps from within, that possibly tend to inevitable lowering of the present standard. The influx of foreign population, if continued at its present rate, threatens to create a competition in wages, and a demand upon supplies for subsistence, that tend to depression of the average plane of living. It is a possibility that looks too much like a strong coming probability for satisfactory contemplation. But we have nothing to do with the inevitable. "*Shall it be maintained?*" involves the will and determination to uphold it by all the means that legislation, organization, enlightened public sentiment, justice and fair dealing between employer and employee, can command. Our population has doubled in less than thirty years. There is every reason to believe that it will exceed the present population of Europe before the end of the next century. With five times the present number of people to feed and clothe, can they be fed and clothed as well? It may be, if they continue industrious, if the proportion of non-producers does not increase, if labor shall be distributed harmoniously in production, and if the laborer can secure a just recompense. If the present disregard of the requirements of national economy in production shall continue, if we remain idle at home and go abroad to supplement the deficiencies created by our own inertia, a lower level will be inevitable. If our farmers fail to produce the material required for food and clothing, if our manufacturers neglect the fabrication necessary for our wants, the sum total of production will be relatively low. Divide the value of production by the numbers of the people, and the quotient will represent the sum available *per capita* for consumption. If by reason of lack of industry or skill that sum is reduced twenty per cent the scale of individual living must be reduced twenty per cent. If the farmers of India produce only a value per head one-eighth as large as that of the farmers of the United States, it accounts for the perpetual semi-starvation of the Indian people. The anomaly is presented of so large a proportion of farmers that existence is ever in the border-land of famine. In Europe, for example, Great Britain, Austria and Spain represent three degrees of production, and a similar gradation necessarily exists in consumption—in wages and standard of living. Something cannot come from nothing. No nation can consume more than it produces.

FACILITIES FOR PRODUCTION.

It is useless to ask what natural productions we can profitably grow. What can we not grow? is a more appropriate question. All the cereals, the esculent tubers, nearly all the fibres of commerce, the fruits, sugar producing plants, many of those used for medicines and dyes, are of easy and remunerative cultivation. It has often been said that oranges and lemons could not be grown, because they do not thrive in Vermont; now the domestic product is taking possession of our markets and commanding the highest prices. It was once deemed the evidence of economic madness to dream of the cultivation of pineapples and bananas; now they are produced with profit and promise of great extension in southern Florida. The raisins of California are superseding those of Spain, and prunes are taking the place of those of France. And all these semi-tropical fruits have reduced the market prices just in proportion to the extension of domestic production.

When our population shall reach 350,000,000 people, if the average consumption shall be reduced it will be from neglect and failure of domestic production rather than limitation of the power to produce. Not one-sixth of the area of the South is producing, and of that portion scarcely half the measure of its possibilities. The vast Rocky Mountain section, with its great resources of fertility aided by irrigation, is scarcely touched by the cultivator. Other portions of the country possess large capabilities for enlargement of production. Our agriculture is as yet unscientific in method, limited in range of cropping, and crude in practice, with only exceptions enough to prove the general accuracy of the averment. There will be no necessary difficulty in supplying all the requirements of food and of clothing, with the increase of population indicated, without any reduction of the present standard of living.

EXPORTATION OF SURPLUS PRODUCTION.

As the scale of expenditure must be limited by income, by wages, the rate of wages must be maintained or the standard of living will inevitably be lowered. Without reduction of wages and decrease of cost of manufacture, is enlarged exportation of surplus products possible? If not, it will be better to live well at home, without a surplus, than to live meanly in order to help foreigners to better living.

By comparing our increase of population, to be fed here, with the increase of foreign dependents on our surplus, we find at least twenty new domestic mouths to fill for every one in foreign lands. In the last decade there has been decrease; in the previous one there was considerable increase. Only crop disaster, threatened famine abroad, can enlarge the foreign demand. While our population is enlarging at the rate of nearly two millions per annum, our increase of production will be needed mainly at home, and it is an even question whether the foreign requirements will increase or decrease. It is therefore clearly apparent that the demand for augmented production will come mainly from growth of the population of the United States. This makes the exportation of the surplus of agriculture a matter of small comparative importance, and of manufacture a minor consideration.

But the record of the growth of exports of domestic manufactures does not warrant the assumption that higher wages are an inevitable bar to exportation. Such exportation in the last twenty years has much more than doubled, while the increase of population was only 70 per cent. There is a constant tendency to greater effectiveness of labor by the acquisition of skill, and especially by inventions and ingenious appliances for the saving of labor.

Agricultural machinery affords a striking illustration of the possibilities of exportation under a scale of high wages. While the labor in this manufacture has been made highly efficient by systematic training and subdivisions of processes, the reason for exportation is not found in the labor cost of the goods. Invention, adaptation of machines to their uses without loss of power, strength without clumsiness, superior effectiveness, are the causes of preference, with little reference to the muscle required in their fabrication. These qualities have a mental rather than physical origin; it is mind and not muscle that enters into the cost. There is a point, however, of physical advantage. So far as wood enters into their construction there is a natural superiority over European material in the superior toughness and strength of American woods. Considering all these differences, which render our agricultural implements distinctively American and manifestly superior, our farmers would not accept foreign machines if they were given to them. The value of such exports was \$1,087,580 in 1869 and \$3,623,769 in 1889.

Carriages and horse cars, also, are sought abroad, not because

of the labor cost of their manufacture, but in spite of it, their style and convenience outweighing all considerations of cost. The increase has been from \$404,796 to \$1,664,284, and in addition, passenger and freight cars, not exported twenty years ago, were last year exported to the value of \$1,426,234, making a total of over three million dollars.

The increase in leather and its manufactures is more than ten to one, the total being \$10,747,710. The exports of wines has also increased over 1000 per cent. Manufactures of copper have increased 1836 per cent, and copper ore, 8067 per cent, together making an export value of \$9,867,212. In the staple manufacture of cotton cloth, in direct competition with the factories of Europe, there has been an increase of 74 per cent, or from \$5,874,222 to \$10,212,644; and in iron and steel an increase of 95 per cent, from \$10,873,950 to \$21,156,109.

Thus, in certain manufactures, in which the cost of labor has been double that paid by foreign competitors, exports have increased beyond the advance in population, in some cases ten, twenty, even thirty fold. This ability to export, notwithstanding the higher rate of wages, is not as yet general, but the above citation of fact illustrates the possibility, yea, the certainty of gradual enlargement of the list and especially the volume of exportable goods, partly through superior skill and efficiency of labor, and perhaps in larger part from labor saving machines and processes, and from the distinctive peculiarities and marked availability for their intended uses in the manufactured goods. The ability to export, therefore, is less a matter of muscle of the mechanic than of inventive power and of cultivated intellect in the forms and adaptations of the thing manufactured. The higher wages may thus be neutralized by the aid of mind far more than of muscle.

CONCLUSIONS.

An analysis of the facts that illustrate the standard of living in the United States leads to the inevitable belief that the people, the workers in all the hives of industry, the constructive forces of the nation, exist upon a higher plane than those of any other country. The following results of this investigation are presented:—

1. The American citizen is free from the bondage of feudalism, from the domination of kingly or aristocratic mastery, and from the control of caste. He is an independent individual, a sovereign

in his own right, voluntarily submitting to laws of his own making, to limitations of natural rights for the general welfare. His aspirations are checked only by a wise judgment of his capacity, and his elevation in the walks of life is limited only by his ability and opportunity. He is the master of his own career and the maker of his own fortune.

2. Inducements to action lead to activity in effort; intense and persistent application causes waste of tissue, of nerve and muscle; and a liberal ration becomes necessary for repair of waste. The opulence of nature makes rich provision for the largest alimentary liberality. Therefore large consumption of all the elements of nutrition is assured, fully fifty per cent more than that of the average in Europe, and more than twice as much as that of the less favored peoples of the world.

3. The variety and abundance of vegetable and animal fibres, by the favor of soil and climate and the energy of man, are no less remarkable than the range of species and ease of cultivation of the grains and fruits. The development of taste and the effort to rise in social life conspire to create an extraordinary demand for clothing, so easy to gratify and so increased by the facility of its gratification.

4. It is a natural corollary of these facts, as stated heretofore, that "the satisfaction of dietetic and sartorial demands of our people is no more imperative than the urgency of their requirements for home-making and ornamentation." Liberal demands in food and clothing are only consistent with a high appreciation of comfortable housing. Bed and board are indissolubly joined.

5. Such a scale of expenditure presupposes a higher rate of wages, a larger income than that of average peoples. The facts show that our wages are from fifty to one hundred per cent higher than those of the workmen, in their several classes, of the most favored nations, twice as high as the average of certain countries, and three times as high as that of certain others.

6. With seventy acres of land for every farm worker, three hundred and fifty bushels of cereals for each, with abundant industrial or surplus crops, meats, fruits and vegetables in equal abundance, and markets greedy for the surplus, the farmer is in condition to live and thrive, or know the reason why his profits do not meet his expectations.

7. The question arises, *Shall the present standard of living be*

maintained? It is a point upon which hang "the future education, enterprise, independence and prosperity of the people" of the United States. It depends on the industry of the producing classes, their wisdom in the distribution of their labor towards a production that shall meet their wants. If idleness shall be encouraged, production limited, importation enlarged, and dependence on foreign countries fostered, wages will be reduced, and the ability to purchase, as well as the volume of production, will decline. If the advice of public and private teachers of repressive economy, to buy everything abroad and sit down in the engagement of the luxury of laziness at home, shall become the law of the land, short rations will follow, and high prices will only be abated by the inability of our people to purchase for consumption.

8. If, on the other hand, we determine that there shall be no decline in production, agricultural or other, we must provide for it manfully by our labor, realizing that no nation can live beyond its income, or consume more than it produces.

9. Unless the largest variety of production shall be encouraged, and the highest skill shall be stimulated in the endeavor to meet all the wants of our people by the results of our own labor, it will be impossible to have a surplus for export. The example of Spain and India, in contrast with that of England and Belgium, or of France and Germany, enforces this conclusion. But in view of the fact that high wages must coexist with a high standard of living, as the history of wages in all countries shows, can we export a surplus produced by high wages? Our experience of the last twenty years shows that our exports of domestic merchandise, produced by the highest wages of the world, have increased much faster than population, some a hundred, some a thousand fold. Not because of the fact of high wages but in spite of it, not so much by the force of muscle as by the creative power of mind. The creations of invention, in the lines of taste and utility, adaptation and expedition, can nullify the obstruction of high wages for more than advance in skill and manual dexterity. It is a matter of time, of determined effort, of high endeavor, to render high wages consistent with large exportation of surplus, but the future will accomplish it, if the present scale of living and rate of wages of the American people shall be maintained.

PAPERS READ.

THE RIGHT APPLICATION OF HEAT TO THE CONVERSION OF FOOD MATERIAL.

By EDWARD ATKINSON, Boston, Mass.

INTRODUCTION.

IN dealing with this question again, I shall be obliged to repeat some part of what I presented at the Toronto Meeting, in order to make this paper a fitting introduction to the reports of Mrs. Richards and Mrs. Abel, which are submitted with it.

At the meeting of the Association held at Ann Arbor in 1885, I presented an address before Section I, which (so far as my own part of the work was concerned) was mainly devoted to the statistics of the Food Supply. To this statistical treatise was added a most valuable paper by Professor Atwater, containing dietaries scientifically prepared, at various prices for a day's ration. After I had given this address and had become very greatly interested in this branch of economic science, it became very evident that one might print and publish treatises upon the subject to an almost indefinite extent but they would fall dead and would be practically useless unless some way could be devised for the conversion of food materials into nutritious food by which the practice of cooking should be practically revolutionized. I began experimenting in a crude way on methods which I had started upon many years before, but my attention being turned in other directions I had then dropped the subject. I succeeded in making what became known as the Aladdin Cooker, a bit of apparatus in which food could be simmered and could be readily converted into a nutritious form at a very low cost. This conception or invention I attempted to give away, thinking that it might be taken up without being forced into use by any organization established for the purpose of making a profit on the manufacture.

But this plan did not work. I had a curious experience in finding out that one cannot give away an idea. I ought to have known this before, from my economic study of the methods of business. I ought to have realized that profit is the incentive to progress, and that giving away is not, in the long run and as a common rule, profitable either to him who gives or to him who receives.

In my experience with this apparatus, however, it also became very apparent that the people of this country would not be converted from their bad methods of cooking by any apparatus in which merely stewing or simmering could be accomplished. I then began in a somewhat empirical way to make experiments upon the effect of dry heat in the conversion of food materials into food; and I presently found out that the science of cooking depended wholly upon the cook being able to measure and control the heat

Every good cook learns this in practice, but how few good cooks there are; while fewer yet practise the right measure of control, because in practising this fine art, the cook is cooked by the heat about as effectually as the food itself. In other words, in the ordinary practice in the use of the cast-iron stove and range, the degree of heat is controlled mainly by dealing with the food itself when subjected to it, rather than by regulating the heat at the point of combustion. The cast-iron stove and range, especially when worked with anthracite coal, cannot be regulated. The measure of the draft necessary to promote the combustion of the fuel of necessity makes too great a degree of heat in the oven or on the stove to render it possible to deal with the food in a proper way except by constantly watching it, stirring it, changing the position of the pots and pans, and by various other empirical devices known but to few and practised by a less number of those who call themselves cooks.

On further investigation it became quite apparent that the process of converting crude material into nutritious food through the application of heat to it is rather a fine process of "chemical reaction" (if that is the right term—I am not a chemist), and that unless an apparatus could be devised in which it might be nearly impossible to overheat or burn the food the work would be badly done.

Now what can be expected in the result if we put appliances which are not fit to be used—like our cast-iron stoves and ranges—into the hands of persons of very moderate intelligence, for the purpose of working a rather delicate and fine process of chemical conversion? Could anything else be expected than what we get, namely,—good material converted into the most indigestible form by the most wasteful methods? I should amend the old saying "The Lord sends the meat and the Devil sends the stoves."

I have taken as an example of this fine process of chemical conversion, the common methods of dealing with the coffee berry. If the coffee berry is dried, ground, and made into an infusion, without being subjected to heat, no good results are attained; the liquid infusion is undrinkable. If the berry is subjected to heat so as to be burned or considerably carbonized, or to a heat at too low a degree, then ground and made into an infusion, the result is an acrid, unpleasant liquid. If the berry is subjected to the right degree of heat for the right length of time, then ground and made into an infusion, we get good coffee. The flavor and the other properties of the coffee berry are developed by the right application of heat or by a process of chemical conversion under the influence of heat. Which is it? Will the chemists please tell us what we really do when we apply heat to food material.

Every one knows how difficult it is to roast the coffee berry over a stove or range: the heat being under no control, the berries themselves must be kept from burning and from being irregularly roasted by constant stirring. Few are capable and few are willing to do this work in the right way. When the work is done on a large scale by machinery it is well done only because the heat can be controlled at an absolute measure in the process of doing the work with proper mechanism.

The same rule which affects the coffee berry also affects grain, meat, fish, poultry and vegetables. Unless the heat applied to either can be established at the right point and then be controlled and regulated, the work is not well done: the fats are dissociated and rendered indigestible instead of being converted into a nutritious and digestible form; the fine flavors are wasted and the house is infested with odors. The measure of the waste of material and of flavor may be measured in proportion to the odor generated by the cooking stove and the cooking range.

Having reached these conclusions, I endeavored to make an oven in which I could control combustion and to which I could apply a regulated and measured degree of heat to each kind of food. After many cumbrous and costly experiments in developing this apparatus, I finally reached a very simple method of construction. But from the beginning to the end, although my first apparatus was costly, cumbrous and for a long time unsuitable for common use, I made not a single failure in dealing with any kind of food, because I was working on the basis of a true theory; to wit: the theory of applying a moderate, regulated degree of heat to each kind of food for a sufficient time. This apparatus, known as the Aladdin Oven, I have protected by a patent.

It has taken me two or three years to convince even myself that my plans were established on solid ground and that I had really achieved success. I have made arrangements for the manufacture of the Aladdin Oven in a moderate way, keeping the general supervision of the work in my own hands with the hope and expectation that ere long under the protection of the patent, it will become expedient for some large establishment to begin to manufacture the ovens and to introduce them on a large scale. My experiments have been at considerable cost; it is my intention to recover that cost as soon as may be from the profits of the manufacture of the oven as at present established. When that has been accomplished it is my intention to conduct the manufacture of the oven either under my own supervision or under contract on a strictly commercial basis. But as I do not intend to make this work a part of my own means of subsistence, I shall devote the profits, if any, after I have recovered the cost of my experiments, to the further development of the science of nutrition. In this work I have been greatly aided by the counsel of Professor Atwater; and I have been enabled to coöperate with Mrs. Ellen H. Richards, who with Mrs. Mary H. Abel had established the New England Kitchen in Boston, with a view to diffusing right information in the community as to the kind of food that it would be expedient for them to consume and the right methods of preparing it by the use of the apparatus which is in common use.

It was desirable, however, that Mrs. Richards should have the support necessary to carry on a scientific investigation at the same time that she was conducting this practical work of reform. To the end that this scientific work might be done in connection with, but not necessarily as a part of the main purpose in establishing the New England Kitchen, a grant was made by the Trustees of the Elizabeth Thompson fund; two of my friends also made unsolicited contributions in money. By the use of these funds

a certain amount of excellent work has been done on the scientific side. With this introduction I venture to present to the Association a copy of the report of Mrs. Ellen H. Richards to the trustees of the Elizabeth Thompson fund; and also a copy of the report of Mrs. Richards and Mrs. Mary H. Abel on the scientific work accomplished by the aid of the funds which had been placed in my hands. These latter reports are devoted to preparing meat and milk.

A beginning has been made upon the bread question. From my own investigations I have proved that the process of kneading by hand in making bread is entirely superfluous. I have also proved in common practice in my own family and in other places that perfect bread can be made at the minimum of cost without the hand touching the dough. This bread is raised in the Case Bread-Raiser and baked in the Aladdin Oven at the exact temperature required.

A complete treatise on the science of bread making will hereafter be presented; but for the moment, information upon that subject, which would not properly come into this treatise, may be found in a pamphlet upon the Aladdin Oven, which will be sent on application to Messrs. Kenrick Bros., Brookline, Mass., of which I also transmit copies herewith.

I should not venture to advertise this oven in this way if I had not already declared my purpose to devote the profits, if any, to the further development of the science of nutrition.

REPORT NO. I.—TO THE TRUSTEES OF THE ELIZABETH THOMPSON FUND.

The investigation of certain scientific principles of hygienic and economic cookery in aid of which a grant of \$300.00 was made from the Elizabeth Thompson Fund was to cover four points:—

1. The determination of the time and temperature required for the best results in flavor and digestibility of the several classes of food materials, i.e., meat, vegetables, etc.
2. To ascertain the difference, if any existed, in the chemical character of bread quickly baked and that baked for a long time.
3. To endeavor to secure a simple and effective measure of oven heats.
4. To modify the ovens in common use in order to obtain more digestible food and to secure more economical use of food materials.

The study of these points was made by Mrs. Mary Hinman Abel in connection with the work of the New England Kitchen, 142 Pleasant St., thus securing more than mere laboratory results. The analyses were made in the laboratory of sanitary chemistry of the Massachusetts Institute of Technology, by Messrs. G. L. Heath, F. S. Hollis, W. R. Whitney, and Misses Bragg, Day, Sherman and White. The apparatus is being used constantly in further experiments.

The accompanying Report gives in detail the results of the six months' work. It may be briefly summarized as follows:—

Two standard dishes have been perfected which have stood the test of six months daily sale with constantly increasing popularity. The time and temperature necessary for these dishes are known as well as the exact pro-

portions of the necessary ingredients. Meat and vegetables are represented. The two dishes are beef broth for invalids, and pea soup. From the beef broth other soups are made. We believe this to be the first time that standard dishes have ever been prepared on scientific principles with such exactness that they may be duplicated, in every particular, like an apothecary's prescription. Besides these, several dishes have been prepared with, we believe, more careful and intelligent study as to methods and food value than has ever before been bestowed on this class of food in this country.

2. The change in the composition of bread when baked a long time at a moderate temperature has been demonstrated as will be seen by reference to the tables of analytical results. This branch of the subject is still under investigation.

3. The question of an oven thermometer has not been satisfactorily settled, nothing which was obtainable answered the purpose with sufficient exactness and in view of our conclusions in regard to the use of stoves it was not thought best to pursue the investigation further.

4. In regard to the American cook-stove we have come to the conclusion that no general improvement in the character of prepared food can be expected with so crude and unreliable a means. As we have demonstrated that for most substances a long time and a moderate heat is required for the best results, we must find an apparatus to secure this. Nothing which we have seen or heard of quite meets the ideal requirement. No hotel or restaurant kitchen have we found, in which the apparatus is made with regard to definite scientific principles. All such methods are exceedingly wasteful of heat and of the nutritious properties of the foods.

In our practical experiments we have confined ourselves to the effect of a moderate degree of heat, continued for a considerable time. We have not considered to any extent the methods of broiling or so-called roasting because it is well known that only tender, high-priced cuts of meat can be thus made fit for the table.

We have, however, procured the best type of gas apparatus for this purpose, and later we shall have some results on the subject.

Neither has the cookery of fresh, green vegetables been taken up. Only the points which seemed most vital to the whole question could be covered in the few months at our disposal.

We have also limited ourselves thus far to such apparatus as is applicable to household and hospital uses, and have not considered large steam plant for hotels or co-operative kitchens, although that is the next desirable step to be taken.

ESSENTIALS FOR GOOD COOKING APPARATUS.

For ordinary cooking apparatus the following are essential points:—

1. The degree of heat should be under perfect control, increased, diminished or withdrawn at will, and without loss of time. This can only be perfectly attained with liquid or gaseous fuel. Solid fuel demands constant and equable running, and gives best results in large masses. The

small fire-box of a cook stove, and the urging of the fire for a short time three times a day are fatal objections to the use of anthracite.

2. A tightly closed vessel heated by steam, or hot water, or hot air, offers many advantages over the top of a red-hot stove or the inside of a nearly red-hot cast-iron oven for cooking, except for the broiling and the roasting of meat and for some other methods of cookery which require the quick application of heat.

3. For all purposes of slow cooking the oven should have a non-conducting covering which retains the heat where it is wanted, and also allows of tight closing and of security from the constant watching required by the fitful heat of a stove.

This use of a close oven with a non-evaporative atmosphere, seems to be the secret of the retention of the delicate and volatile flavors which usually flavor the house and street, and not the food as it is brought to the table.

Three kinds of apparatus are now in the market which meet more or less of these requirements, and all may be used with a kerosene lamp. The Arnold Steam Cooker uses steam generated in a sort of flat boiler. For some purposes, such as the cooking of cereals, as mush, and also for the preparation of a few quarts of soup, and for the slow cooking of meat in its own juices, we find this cooker very effective. The liability to leakage and the difficulty of mending are drawbacks, and there is no non-conducting covering.

The Wanzer Cooker we have not been able to purchase as it is held by an English patent. It has a special lamp of some merit and it has good points as the demonstration which the patentees gave us showed. The loss of heat is however very large and the lamp will run only four hours.

Both of these cookers are in the market in rather small sizes but for small families offer a convenient means of securing good cookery.

The Aladdin Oven or Covered Stove. This is a square or oblong box of sheet iron of any desired size, with a non-conducting covering of magnesian cement or wood pulp, and is heated with a kerosene lamp or gas burner. The size in use for these experiments is 18 by 12 by 14 inches, and gives a cooking space at least equal to that of a No. 8 Crawford cook stove, and when empty can be heated to about 800° F. in an hour, and maintain that temperature for eight hours by a single kerosene lamp of the Rochester burner type, with the consumption of one quart of kerosene. When well filled with food materials in small portions the heat is sufficient to heat them in about twice the time allowed by an ordinary cook stove. When the space is completely filled with a vessel containing for instance forty pounds of meat and bone and fifteen quarts of water, the whole is raised from a temperature of 70° to 180° F. in seven hours, and to 212° in twelve hours. If the lamp is then taken away or allowed to go out the temperature does not fall below 190° for four hours.

For this twelve hours, one and one-half quarts of kerosene are needed, or a gas burner can be used. For simplicity, effective use of heat, economy of fuel and development of flavor in the food cooked, combined with increase of its digestibility, the Aladdin Oven is an apparatus far exceeding

in merit any other now in market. It will not meet all the demands that the modern cook now makes of the kitchen stove, and it may be in several respects improved, but in the application of well known and long tried scientific principles to the cookery of food, it is a distinct advance and a most valuable invention.

There has also been designed and put in use a gas table for direct heating of water and other liquids. The great advantage of gaseous fuel, that of per ec control, is here demonstrated.

Certain incidental investigations as that of sterilized milk will be found in the Report. The money has been expended as follows:—

Apparatus	\$100.00
Experimental work	50.00
Analyses of the product	150.00

While only a beginning has been made in this line of work we believe that it has been a real beginning, a distinct departure which we hope will be followed up until the food of the household and the means of preparing it shall receive its proportionate share of the time and attention of scientific men, and we desire to express to Mr. Edward Atkinson and to the Trustees our appreciation of the opportunity thus given us to increase the scientific value of our work at the New England Kitchen, and to lay the foundation of what we believe will eventually prove a Kitchen Experiment Station.

Respectfully submitted,

ELLEN H. RICHARDS.

BOSTON, AUGUST, 1890.

REPORT NO. 2.—TO EDWARD ATKINSON AND THE CONTRIBUTORS TO THE FUND MADE USE OF IN THIS INVESTIGATION.

Cookery of meat.

The ideal preparation of a food for human use requires that the nutrient it contains should be utilized to the fullest extent and this implies not only that it shall be in such a state that the digestive juices can best act on it, but that these digestive juices shall be properly stimulated to do their work by the taste or flavor of the food.

Therefore in the cooking of meat we undertook to answer this question: What method can be employed that will yield the most in nutrition and flavor? It was determined to experiment first with beef of the cheapest cuts, as the neck and shin, these cuts although tough being among the richest in nutrient as shown by analysis, and to utilize this nutrient in the form of broth, or as a basis for soups.

In examining a shin of beef we find it to consist, as far as our uses are concerned, of first, muscular fibre; second, connective tissue; third, bone. We have here three distinct food materials which, if treated separately, would require quite different processes.

1. Muscle fibre.

To prepare this for the digestive juices requires only that slight application of heat that develops the flavor which is most agreeable to the civilized palate, and so increases the nutritive value of cooked muscle fibre over raw, at least for the civilized stomach. A familiar example of the most perfect method of cooking the muscle fibre alone, is broiling.

2. The connective tissue and tendons.

We find these intimately connected with the muscle fibre, and their food material is finally obtained mostly in the form of gelatine. To render these substances available for food they must be first hydrated, and then to a greater or less extent dissolved. The length and difficulty of this process differs with the age of the animal, its food, and also on the length of time the meat has been kept after killing, all of which affects the toughness of the enveloping membrane. The connective tissue in a sirloin steak is so tender that the heat necessary to cook the muscle fibre, as in broiling, is sufficient also to hydrate the connective tissue by merely heating the water contained in the steak; that of the tougher cuts like that of the shin needs a much longer application of heat.

3. The bones also contain a substance which yields gelatine, and to extract it requires a long application of heat.

It became evident at this step in the investigation that since muscle fibre, connective tissue, and bone must be cooked by the same process, and that this process must be a long one in order to effect the necessary changes in the connective tissue and the bone, some means must be devised to prevent the over cooking of the muscle fibre from dissipating its flavor.

This settled the first requirement of the cooking vessel to be used, namely, that it must be tightly closed. On this account the ordinary iron pot was rejected, but the long famous Papin Soup Digester with its tightly screwed top was given a good trial on the kitchen range.

But other requirements were to be met. The perfect hydration of the gelatine yielding connective tissue of meat and the proper cooking of the albumen would require that the temperature be perfectly under control. It was found to be impossible to regulate the temperature inside the digester; for, added to the ordinary difficulty found in using the variable kitchen range, was the fact that the tightly closed digester gave no sign of the rising temperature till the mischief was done. Placed over the more easily regulated flame of gas or kerosene so large a vessel showed great unevenness in the temperature in the top and bottom, and both of these methods were expensive as to fuel.

We next tried cooking the meat in earthen jars placed in the Aladdin Oven to which the heat of a kerosene lamp was applied, and the results obtained were so good that it became evident that we were on the right track. The meat and bone placed in a jar and covered with cold water rose slowly and steadily without any attention on the part of the cook, to a required temperature and could be held there for any length of time by simply lowering the flame of the lamp. The non-conducting shell of the oven assured nearly the same heat to the bottom, top, and sides of the cooking vessel, and did the work with a minimum amount of fuel.

We had aimed to produce a food that should hold nitrogen compounds in solution with all the flavor available. This would require that the extraction of the food material from the meat should be effected as nearly as possible before that temperature was reached at which the flavor once developed would be dissipated by the escaping steam. It was found by later experiment that the agreeable flavors peculiar to boiling soup were not brought out till the boiling point was nearly reached. This by our present method is twelve hours after the beginning of the cooking, and near the end of the process, so that the least possible quantity of these flavoring substances is lost by further cooking.

We therefore had a tin-lined copper vessel holding thirty quarts made to fit the oven, thus utilizing the entire inside space. Three of them have been in constant use in the kitchen since our early experiments demonstrated their value. By this method only, have we been able to meet our requirements for the proper cooking of meat of the tougher cuts, and at the same time extract from bone and tendon a due amount of gelatine. We consider it quite probable that a steam apparatus might be devised that would do the work on exactly this same principle by surrounding the cooker with a heated medium easily regulated and using low pressure; the steam jacket of the restaurant does not answer the requirements, but to have something of this kind constructed did not come within our means.

Whether the Aladdin Oven is the ultimate best form of a cooker we do not attempt to say, but it certainly deserves a high place because constructed on the principle of holding the heat to its work by a non-conducting covering, and for using an easily regulated fuel. Other contrivances examined by us, however convenient and ingenious, are on the old lines and show no distinct advance toward an application of scientific principles to cooking methods.

The method employed in the Aladdin Oven is the same whether the meat and bone are cooked with a small quantity of water and used in the form of a stew, or with a larger quantity of water, the meat at the end of the process being pressed dry of its juices. This latter method is the one most employed at the Kitchen because of our large consumption of this broth, merely salted as beef broth for invalids, and as a basis for our various soups.

COMPOSITION OF BEEF JUICE, BEEF TEA, ETC.

In view of the unexpected demand for the broth for the sick room we were obliged to study the composition of the various preparations in use and the possibilities of the yield of meat under various kinds of treatment.

"Beef Juice" obtained from the best steak which has been merely warmed through over the coals and then entirely deprived of soluble substance by a screw press is undoubtedly the most concentrated of the liquid foods. If prepared with the most scrupulous care, from the best material, and used at once, it probably leaves nothing to be desired. But in unskilled hands the risks are considerable in using this raw and most easily putrescible material. It is also a slow, laborious and expensive operation.

"Beef Tea," as ordinarily made, is of uncertain composition; it may be only the juice of the meat set free by the coagulation and shrinking of the fibre on heating. Such is the beef extract made by heating chopped steak in a bottle. It may be an aqueous infusion of very variable strength containing chiefly phosphates, kreatin, and certain extractive matters, agreeable to the palate but of little nutritive value.

It occurred to us to prepare on a large scale a broth of constant composition from both meat and bone, in such a manner as to secure a nutritive value at least equal to that of milk (without its fat), and without sacrificing the appetizing flavor. The bone gives a proportion of gelatine which, when flavored with the meat extract, is believed to be of high nutritive value.

The following table gives a comparison of these different preparations.

	% of meat.	Total solids.	Solids, juice filtered before coagulation.	Solids, juice filtered after coagulation.	Coagulable albumen.	Extract, % of meat.	Salt or ash.
"Beef Juice" from meat slightly broiled and pressed, Round.	26.8	11.9	10.8	4.98	6.97	3.90	
ditto, Neck.	21.9	9.9	9.4	4.73	5.18	3.56	1.38
"Beef Tea," chopped beef heated in a bottle without water.	26.4	7.91		5.72	2.19	2.09	
"Beef Tea," New England Hospital, with water.		8.23		2.55	0.08		
"Beef Tea" with equal weight of water 2 hours at 73° C. then boiled 2 hours.						2.15	
"Beef Tea" with twice its weight of water 2 hours at 70° C. then 2 hours at 85° C.						2.02	
"Beef Broth," New England Kitchen, average of 26 analyses.		8.53				4.40	

It will be seen that the yield of lean beef to water is only about two per cent, that is to say, from three pounds of juicy steak only about one ounce of solid matter is obtained. The broth of the Kitchen adds to this two per cent from the meat, two per cent of gelatine from the bones.

The following table gives the analyses in detail which have been made in the past six months, eight-tenths of a per cent of the total solids being salt added for flavor, about 0.2 per cent are phosphates from the meat, and the total nitrogen is about 0.4 per cent.

ANALYSIS OF BEEF BROTH.

DATE.	TOTAL SOLIDS.	ASH.
Jan. 22, 1890,	4.19	1.31
" 24, "	4.85	1.40
" 25, "	3.43	1.34
Feb. 4, "	3.88	1.18
" 5, "	4.13	
" 9, "	4.58	
" 11, "	5.00	
" 12, "	4.93	
Mar. 19, "	3.82	
" 20, "	4.13	
" 21, "	3.60	
" 23, "	4.80	
Apr. 24, "	4.32	
" 30, "	4.79	
May 1, "	4.96	
" 3, "	4.55	
" 15, "	3.29	
July 15, "	3.86	
" 16, "	4.43	
" 17, "	5.01	
" 18, "	4.01	
" 19, "	4.86	
" 22, "	4.48	
" 23, "	4.84	
" 24, "	3.71	
" 25, "	4.77	
Average,	4.83	
Average less 0.8 per cent salt,	3.53	1.27

The complete method now applied daily in the New England Kitchen in the making of this beef broth for invalids is as follows:—forty pounds of *well cleaned meat* and bone in equal quantities, the meat cut in thin slices, the bone broken in pieces, is put into the Aladdin Oven in a cooker as described, fifteen quarts of cold water are added, the lamp under the oven is lighted one hour previous to this and heat is then applied for twelve hours, and three pints of kerosene are used. After the lamp goes out the soup is left untouched for three hours, the cooking being continued by the heat still held in the oven. The broth is now strained from the meat through a collander and made up to twenty-five quarts with boiling water which is poured over the meat and bones and strained through a fine strainer. Six ounces of salt are added.

HOW LONG BROTH MAY BE KEPT.

We have taken some pains to determine how long this broth will keep under different conditions, an investigation in the field of household bacteriology. We have settled for our own practice the great importance of:

1. Sterilizing with boiling water every utensil used in the process.
 2. Rapid cooling of the broth as soon as made, to below the temperature most favorable to the growth of bacteria.
 3. Keeping the broth at as low temperature as possible.
- As a result of several experiments during the hot days of July it was

found that broth which spoiled in twelve hours in a cellar where the thermometer stood at 70° F. kept sweet for seven days if placed while still hot in small jars in an ice-chest at 32° F. the cake of fat on the top remaining undisturbed. More complete work in this line is to be done. Canning this broth has been suggested but it seems at present to be impracticable.

The rich but tough meat from the neck of beef is made into an excellent dish by cooking it in its own juice in the Arnold Steam Cooker. This is an application of the same principle of long, slow cooking in a partially non-conducting vessel. The Arnold Cooker is a very good apparatus for small quantities and where no regard is had to economy of fuel.

PEA SOUP.

Of our many experiments in the cooking of cereals and vegetables we consider only one complete and satisfactory enough to report upon. The principles here demonstrated can, however, be applied to many different dishes.

On account of the high food value of the legumes and the general impression that as ordinarily prepared they are indigestible we determined to make careful experiments on methods of cooking them. First we undertook to make what would be a standard soup out of the dried split pea. We found that in this case also the principle of long slow cooking was the secret of success. The ordinary kitchen rule is that the pea and bean is cooked sufficiently when it will mash between the fingers, as the cook says "When it is done it is done and what is the use of cooking it any longer?" But careful examination shows that at this point the vegetable may still be slightly granular and quite lacking in the rich flavor that longer application of heat develops. It was found that not until the split pea was cooked four or five hours, was the result that thick *purée* of rich and mellow flavor that has been so popular in the New England Kitchen. Here again ordinary methods failed us, for in this length of time the soup was certain to become burned. We again had recourse to the Aladdin Oven and found it to answer our needs. The soup is cooked during the night without any care, the result being always the same in taste and appearance. This soup has not been analyzed.

In the cooking of at least two dishes we have proved that a kitchen may approach a pharmacy in exactness, and we have reason to believe that these methods will in time be adopted in hospitals and diet kitchens, as being exact and very economical, both of material and labor, and as furnishing most nutritive food.

The reasons why principles already ascertained in the science of nutrition have been so little applied would seem to lie in the fact that cookery is not conducted with accuracy; that scarcely a dish can be named which has in different countries or even in different kitchens of the same country a constant composition. Any discovery in the use of drugs is immediately disseminated among physicians because of the universal and standard pharmacopœia.

The final step in the establishment of standard dietaries seems to wait for standards in cooked food.

The Records of the Kitchen will be available as a basis for future study of food values, and many observations which are not complete enough to be included in this report will be useful in future work.

Respectfully submitted,

MARY HINMAN ABEL.

ELLEN H. RICHARDS.

Boston, Aug., 1890.

REPORT NO. 3.—TO EDWARD ATKINSON ET AL.

MILK.

To explain why we considered it to be of great importance to furnish a safe milk for infants and invalids, and, secondarily, for household use, it will be well to state what we find to be the present condition of the milk supply in our large cities.

An investigation into the milk supply of Boston was made during the spring and summer of 1890 by W. T. Sedgwick and John L. Batchelder, jr., whose results will shortly be published. From advance sheets of their report it appears that milk drawn directly from the healthy cow is ordinarily free from bacteria, or sterile. It is, however, so rapidly contaminated in the act of milking, and is itself so favorable a medium for the growth of bacteria, that even "pure country" milk contains hundreds of bacteria per teaspoonful. The time required before this can be distributed in the city is so great that milk arriving by rail in Boston contains about 300,000 per teaspoonful, while that taken from wagons or sold in groceries is older and shows from one to ten millions.

This account is confirmed by what comes to us from other large cities and from Europe where the subject has received more study than with us. The conclusions forced upon us are these:—

1. That a large per cent of the milk in daily use is liable to contain disease germs which may under favorable conditions be communicated to the consumer.

2. That even healthy milk is a highly putrescible substance, which in its raw state offers a most favorable medium for the culture of many kinds of bacteria which grow in numbers and rapidity, depending principally on the surrounding temperature, and that in the digestive tract, especially of young children, in warm weather this partly decomposed milk leads often to fatal results, without doubt in direct connection with this being the fact that from 50 to 70 per cent of the summer deaths are of children under five years.

Various chemicals have been used to neutralize the acids resulting from the activity of these bacteria, but they have one and all been condemned as injuring the milk or as deleterious to the stomach.

It is at present agreed on all hands that only by the application of heat can all of this germ life be destroyed and the milk made safe without in-

juring its food value, and numberless experiments have been made to determine how high a degree of heat must be employed and how long it must be continued. This process is known as sterilization.

EXPERIMENTS IN RATE OF ACIDIFICATION UNDER DIFFERENT CONDITIONS.

	RELATIVE ACIDITY EXPRESSED IN C C H ₂ SO ₄ .						
	JUNE.						
	18	19	20	21	24	25	26
Milk from the contractor, uncooked,							
Heated 20 min. at 62° C.	1.5	9.8	11.0	10.6	11.6	12.7	11.3
" 20 " " 70° C.	1.5	3.0	4.8	6.2	7.5	9.6	11.1
" 20 " " 80° C.	1.5	1.7	1.3	2.4	8.4	8.9	10.9
" 20 " " 90° C.	1.5	1.5	1.1	1.3	7.1	8.6	10.7
" 45 " " 70° C.	1.5	1.0	1.2	1.8	6.0	9.4	12.4
" 90 " " 95° C. after 9 days,	1.5	1.4	1.8	1.5	9.7	11.3	11.0
Evaporated milk, 1 week old,							
Milk from the grocery, 2 days old,				10.4			

1 c.c. NaOH = 1 c.c. H₂SO₄

1 c.c. H₂SO₄ = .0031276 grms. Na₂CO₃.

" = .005311 grms. lactic acid.

1. STERILIZATION.

The simple household method of boiling the milk in an open vessel for a long time will kill germs of all kinds, making the milk a safe food and thereby greatly increasing its keeping qualities. But this method has drawbacks, it changes the taste of the milk giving it a flavor disagreeable to many people. This sterilizing is practised to a considerable extent on the continent in an apparatus invented by Dr. Soxhlet. This was described in a paper by August Caille, read at the meeting of the Pædiatric Section of the N. Y. Academy of Medicine, Feb. 22, 1888, and in this paper we find also the valuable suggestion that legal enactment should provide for the transportation of milk in refrigerator cars during the summer months. How far the digestibility of the milk is affected by boiling seems to be still an open question. An article on the subject by R. W. Raudnitz appeared in the *Zeit. Physiol. Chem.*, 14, pp. 325-327.

The changes wrought in the milk by sterilization according to any method yet used being considerable, it has been sought to destroy the bacteria if possible, at a temperature that would leave the milk unchanged in odor, taste and appearance, as Pasteur killed the wine ferment without spoiling the wine.

This principle has been used in a number of experiments and has led to the invention of ingenious apparatus that is used in Germany for this purpose. By these the milk is brought as rapidly as possible to a temperature of 68°-70° C. and there kept for thirty minutes. It is then rapidly cooled and due care is taken to keep it from re-infection. The result bears

favorable comparison with raw milk in smell, taste, and appearance, and has been proved by what would seem sufficient experiments on animals to be free from pathogenic germs, such as the bacilli of cholera and tuberculosis, and nearly or quite free from saprophytic bacteria, though not from such spores as may be present or develop later, spore formation being comparatively rare, however, in so good a growth medium as milk. It keeps at summer temperature twice as long as raw milk and at lower degrees three or four times as long.

As clearly stated by H. Bitter in an article in the *Zeitschrift für Hygiene*, May, 1890, milk must be sterilized or Pasteurized before it reaches the consumer, and not left to his ignorance or carelessness. Moreover in most cases it is already too late when the milk reaches him, and if a safe milk can be furnished at a price that will compare favorably with raw milk and also be agreeable in taste and appearance, it will be quite likely to obtain in time general acceptance.

EVAPORATED MILK.

In April there came to our notice the evaporated milk made by the Orange County Milk Association. The milk was said to be prepared by simply taking from it seventy-five per cent of its water by evaporation in a vacuum pan at 180° to 150° F., no sugar or other substance being added. By a cursory examination it showed itself when diluted to its original bulk to be in taste and appearance scarcely to be told from the best of fresh milk and its keeping qualities were greatly increased, especially in the undiluted state. We undertook a thorough examination of this milk, applying to it all the tests in our power. A trained bacteriologist was sent to examine the factory and made the following report:

REPORT OF BACTERIOLOGIST.

"The Orange County Milk Association has three factories: at Goshen, Fort Plains and Walton.

Generally the evaporated milk is made at the last two and the super-heated or thicker milk is made at Goshen.

Just now (May 27) the market is stocked with milk, so the two more distant factories have been ordered to make their milk into butter and cheese, and the Goshen factory to make alternate lots of evaporated and super-heated milk, which is enough to supply the market.

If evaporated milk is shipped to Boston it probably comes either from Goshen or Fort Plains, as these are the nearer ones.

The milk is brought in every morning by the farmers and consists of the morning's milk which has not been cooled, and that of the previous evening, which has been cooled over night.

If a large amount of evaporated milk is to be made, all is put into the vacuum pan, but if only a part is needed that of the night before is used and the fresh morning's milk is set to cool.

The evaporated milk is taken down 4 1-2 to 1, while the thicker super-heated milk is only taken down 4 to 1.

The super-heated milk is subjected to a high temperature before it is put into the vacuum pan by blowing in free steam, while the evaporated is only slightly warmed before taking it into the vacuum pan.

During the evaporation the temperature is carried to 190°-200° F. for super-heated, while for evaporated it cannot go over 140°-150° F. without spoiling the product.

The difference in milk owing to the time of year, kind or amount of feed, makes a slight difference of treatment necessary.

The aim is to carry through large amounts of milk in a short time. The evaporator is of copper, seven or eight feet in diameter, capable of evaporating 1400 quarts per hour. The lot carried through on the first morning that I was there was thirty-two times forty quarts, equals 1280 quarts.

The heating is done by a coil of copper pipe inside, at the bottom. The vacuum is maintained by pumps and a supply of cold water, the whole arrangement is much like an evaporator at a sugar refinery.

The milk to be condensed or evaporated is put into two tanks in the basement and connected by pipes with the evaporator, so that the milk is sucked up as fast as water from that already in the pan is evaporated off.

For super-heated or condensed milk, the milk is heated in these lower tanks by blowing in steam, while for evaporated milk it is only just warmed. Thus that part of the milk drawn up last in the making of evaporated milk has been heated for a much shorter time (perhaps only twenty minutes) than the first taken into the evaporator, and these are all mixed in the final product.

The temperature is determined by means of a long thermometer dipping down into the milk, and by the pressure.

When finished both the super-heated and the evaporated milk are drawn off through a long pipe in the bottom into forty-quart cans which are placed in troughs filled with running artesian well water (temperature 45°-48°) and allowed to cool.

This cooling is hastened by putting in paddles with a number of vanes which are moved by connecting with a shafting above. It seems to me that this is a great source of bacterial contamination and I should not think it would be absolutely necessary for evaporated milk, although it is for super-heated milk.

All of the milk is sold in large stoppered cans for immediate use.

They claim that all of their milk is without artificial sweetening.

The farmers are cautioned to be careful in milking, and in the subsequent keeping of the milk, but no other precautions are taken.

The milk is not analyzed, but its quality is judged by its appearance and by the product which it yields.

The following statement gives the result obtained by planting samples taken directly from the vacuum pan and from the cans after they had been cooled.

The cultures required ten days before they were ready for counting.

Samples taken from the charge of the morning of May 28, taken after

about half of the milk had been drawn from the evaporator, showed an average of 1593 colonies per c.c.

Samples of May 29, after drawing off 40 quarts, gave an average of 819 colonies; after 200 quarts, an average of 1048 colonies; after 440 quarts, an average of 865 colonies per c.c.

Samples from cans after cooling to 60° in which paddles had been worked for about half an hour gave an average of 968 colonies."

The milk has been analyzed at various times at the Institute of Technology, and the results are given in the following table:

DATE.	TOTAL SOLIDS.	FAT.
April,	48.40	13.50
July 14,	47.52 47.35 }	13.58
July 15,	51.58 50.97 }	
July 16,	48.50	
" 18,	48.07	
" 19,	45.66	13.62
" 22,	47.55	14.12
" 24,	50.67	13.46
" 25,	49.36	

While this form of "thin milk" has been known in New York for years, its especial hygienic significance seems to have escaped notice, namely, that by restricting the temperature below 150° F. the caseine is not changed as is the case at 190°. This is proved by the fact that the thick or super-heated milk contains a lower percentage of solids than the thin variety, its appearance to the contrary, as well as by the absence of the cooked taste in the thin variety. There seems to us good and sufficient reason for urging a trial of the milk during the hot season.

We have assumed the expense of expressage from New York and of frequent analyses in the interest of sanitary science, and we hope that some investigation will soon be made as to how far the vacuum pan reinforces the temperature. In other words whether a temperature of 130° F. and a low pressure are not as effective in killing germs, if not spores, as a much higher temperature at the ordinary atmospheric pressure. Another point to be investigated is what is the effect of concentration on intercellular osmosis. It is evidently only a question of time when the mode of milk supply for all large cities will be changed.

We placed this milk on sale and asked the co-operation of physicians already interested in our investigations in giving it a thorough trial. As it was well known that we had no pecuniary interest in the milk and only wanted facts, we feel that we have had an unbiased judgment.

It is now three months since this trial began and the latter part of this time has covered some of the hottest weather known in Boston for years. The Boston Dispensary has prescribed it for all its out-door patients (children) and so far with gratifying results. In many cases the child had not been able to keep on the stomach any other kind of milk, or any of the prepared foods, but on the first trial digested the evaporated milk and continued to do so.

One child who has been using the milk for ten weeks and was at the beginning feeble and sickly, weighing at three months only eleven pounds, after being put on the evaporated milk gained three-fourths of a pound a week for five weeks. Since that time we have not been informed of its weight, but it continues to do finely.

The milk has been used since early in June at the Dimmock street hospital for women and children. The physicians in charge inform us that the children have on the whole done well on it even during the very hot weather, and express the desire that it might be within reach of all the babies in their neighborhood.

That the milk is harmless and also digestible, seems to be quite fully proved. We are told by the physicians that its full nutritional value could not be definitely stated without still further tests, though all looks favorable for it.

In our estimation this milk is the most readily found substitute for mother's milk, and it is a safe, cheap and convenient milk for household use.

Our test has been made under the most favorable conditions, in that we have had no control over the manufacture and supply, the milk being probably twenty-four hours on its way to us, and in hot weather. If it were to be introduced as a general supply in large quantities, very careful supervision should be had of its manufacture.

Respectfully submitted,

MARY HINMAN ABEL,

ELLEN H. RICHARDS.

BOSTON, AUGUST, 1890.

THE NATURAL RESOURCES OF LOUDON COUNTY, VA. By MRS. LAURA OSBORNE TALBOTT, Washington, D. C.

[ABSTRACT.]

THE geographical features, geological treasures, soil values and history of settlement and development of this interesting portion of Virginia are carefully presented in this paper. Lying east of the Shenandoah and south of the Potomac, between Maryland on the north and the Bull Run Mountains on the south, the Blue Ridge elevation skirting the western border, the surface is a panorama of great beauty. It was separated from

Fairfax county in 1757 and named in honor of the Earl of Loudon, military commander in the latter part of the French and Indian War. Sergeant John Champe, who made an attempt authorized by Washington to capture Benedict Arnold was a native of this county. Some of Baron de Kalb's descendants still occupy land donated by the government for his services in the Revolutionary War. Oak Hill, the residence of James Monroe, fifth president of the United States, is situated nine miles south of Leesburg, the county seat. Remarkably pure springs, "almost absolutely chemically pure," the Paonian springs, are located here. Marble claimed to be equal to the best Italian is found here. Specimens of pure white, purple and copper-colored, are exhibited, and others resembling malachite and onyx. "Potomac marble," utilized for columns of the old House of Representatives in Washington, has been burned in considerable quantity for lime. It is a region full of interest to the geographer, the geologist, the marble-worker, the cultivator and the lover of beautiful scenery.

THE REFRIGERATING POWER OF TREES. By JACOB REESE, Philadelphia, Pa.

[ABSTRACT.]

TREES are living, breathing beings. Their leaves are their most important organs. By the agency of small openings in the leaves called stoma, the carbonic acid is absorbed or inhaled from the atmosphere and deposited in the chlorophyl which is the laboratory. The carbonic acid is there disassociated, the carbon put into wood fibre and the oxygen exhaled as ozone.

When we burn a pound of carbon to carbonic acid (CO_2) 14,544 heat units are set free; and in the act of disassociation of carbonic acid to wood fibre in the tree and ozone exhaled to the atmosphere, the same number of heat units, 14,544, are abstracted from the atmosphere and made latent in every pound of carbon thus formed into wood fibre.

We thus see that the trees not only purify the atmosphere by abstracting carbonic acid and surcharging it with ozone, but they are also nature's automatic refrigerators for abstracting atmospheric heat and making it latent in the wood fibre.

The wonderful development of railroad business has destroyed and is destroying the trees for ties, bridges, cars and other uses to such an alarming extent and thus lessening the refrigerating power of the forests to such a degree that our summers are getting hotter and hotter every year.

I therefore raise my voice against unnecessary destruction of forest trees. They are nature's atmospheric purifiers, nature's atmospheric refrigerators, and conservators of health and comfort.

THE FOREST AS A NATIONAL RESOURCE. By B. E. FERNOW, Agricultural Department, Washington, D. C.

[ABSTRACT.]

CLASSIFYING the natural resources for the purposes of defining the position of the state towards them, we may divide the resources into those that form directly the basis of material development and are objects of industrial activity and those which, like air, water and climate, are indirectly influencing such development; the former class may again be divided into resources which are exhaustible and not restorable and those which are restorable.

As forest resources, we may consider the virgin forest, or we may conceive the soil and its fertility capable of producing forest-growth as the real resource.

The forest-growth itself, while a material resource and as such classed among the resources which form the objects of individual activity, can by its location or position become a cultural condition, influencing climate, soil and waterflow, and thus ranging in value with the second class of resources. Climatic influence, while probable, is not as yet proved; but the influence of forest-areas upon the flow of water and with it upon soil conditions and upon winds is generally recognized. As a material resource the forest is exhaustible, but within limits restorable.

The virgin forest must be reduced to gain the needed agricultural ground, but when the requirement for food areas is satisfied, it is desirable to treat the forest in such a manner as to secure continued reproduction. This gives rise to forest management or forestry as an industry.

Special considerations and economical peculiarities pertain to forest-growth and forestry, which may influence the relation of the state toward them.

Such considerations and peculiarities are:

1. By its location upon mountain slopes, sand-dunes and otherwise the forest may represent a climatic and cultural condition of paramount importance, which renders its material value a secondary consideration.

2. By mismanagement or neglect the capacity for reproduction may be injured to such an extent as to make reforestation impracticable, if not impossible.

3. Forest-growth improves instead of exhausting the fertility of the soil and is capable of producing useful material on the poorest soils and situations.

4. By proper methods in utilization alone, reproduction of the virgin forest superior in quality and yield can be effected.

5. Forestry differs from other industries in the long period of production, necessitating an accumulation of stocks, which is exposed to various dangers for a long period of time and hence renders the business hazardous.

6. Forestry requires large areas and a large fixed capital, but only small

running capital; it employs little labor but furnishes employment at seasons when elsewhere labor is less needed.

7. As a financial investment, forestry is beset with many drawbacks, which render it less desirable to private enterprise, the necessity of keeping on hand a large stock exposed to danger not rendering it a desirable object of financial operation.

8. Forestry engenders and requires permanence, continuity of plans, management and conservatism.

As far as the forest represents simply a material resource, the position of the state toward it need not differ from that which it takes toward other industries and resources, except in so far as the peculiar conditions of this industry call for special exercise of the protective and persuasive or educational functions of the state. The restrictive and providential action of the state is only necessary to be exercised in reference to those forest areas whose existence and proper condition influence other cultural conditions. Since restriction of private rights is always impracticable and unsatisfactory and compensation of damages difficult to adjust, communal or state ownership of mountain forests is advocated. The ameliorative function of the state is called into play for the reforestation of large treeless areas where private energy is powerless.

BIOLOGICAL FACTORS IN THE NUTRITION OF FARM CROPS. By DR. MANLY MILES, Lansing, Mich.

[ABSTRACT.]

REFERENCE is made to the earlier experiments relating to the sources of the nitrogen of plants, and particularly to the results obtained by Boussingault, and at Rothamsted, which agree in showing that atmospheric nitrogen is not to any extent appropriated by the leaves of plants, and that the soil is the main, or sole, source of the nitrogen of vegetation.

In experiments at Rothamsted with wheat and barley, representing the cereals, it was found that notwithstanding the comparatively small amount of nitrogen in their composition they were especially benefited by nitrogenous manures, while leguminous crops, containing a larger amount of nitrogen, were not benefited by such manures, and that they grew well under conditions of nitrogen supply that were not sufficient for the cereals. Leguminous plants must therefore obtain nitrogen from some source or under conditions that are not available for the cereals.

These facts are explained, in part at least, by recent experiments which prove that the "tuberles" or "nodules" observed on the roots of leguminous plants are caused by microbes, and that "the relation between the roots and the bacterial organisms is a true symbiotic one, each developing more vigorously at the expense of the other," and that free nitrogen is thus made available for the higher organism through the agency of the lower.

The experiments of Hellriegel leading to the discovery of these relations of mutual dependence are noticed, and the experiments at Rothamsted, in 1888 and 1889, with peas, vetches, lupins, red clover and lucerne, which fully verify the results obtained by Hellriegel, are described in greater detail.

In these experiments the plants were grown in pots of clean white quartz sand to which was added a small fraction of one per cent of the ash of the plant under experiment, and this prepared sand was then sterilized by keeping it at a temperature of 100° C. for several days. All were watered with distilled water.

In each series, nothing else was added to one pot, while in two others the prepared sand was inoculated with a small quantity of a water extract of a fertile soil. In a fourth pot plants were grown in a field or garden soil.

After about four and one-half months, the yellow lupins in pot 1, in the prepared quartz sand alone, barely appeared above the rim of the pot, one plant being about 1½ and the other 2 inches high. In the inoculated quartz sand, in pot 2, one plant was about 2 feet high and the other 18 inches, both spreading beyond the width of the pot. One plant in pot 3, also in inoculated quartz sand, was more than 2 feet high and the other little more than 8 inches.

The plants in pots 2 and 3 flowered and seeded, and they in fact made a better growth than the plants in pot 4 (in a soil from a field where lupins were growing) which were but 16 and 18 inches high, and less branching than those in pots 2 and 3.

There was little root development in pot 1, *and no root-tuberles could be found*. In pots 2 and 3 there was abundant root development, with numerous root tubercles, exceeding in this respect the plants in pot 4.

Similar results were obtained with the peas and vetches, but the roots of the red clover and lucerne were not examined, as the plants were saved for a second year's growth.

In all cases luxuriant growth of the plants was coincident with the development of numerous root-tuberles, which were produced by the inoculation of a sterile quartz sand with microbes from a fertile soil.

The term symbiosis, as now used, is limited to the mutually beneficial relations of certain species living together in harmony, but the biological relations of mutual dependence presented by microbes and the plants growing in the soil, may extend to a series of organisms, each of which has its influence on the well being of the others.

The activities of microbes in soil metabolism are not limited to processes of putrefaction and nitrification. In the author's experiments with soil microbes they proved their ability to take their required supplies of lime and potash from solid fragments of gypsum and feldspar, and even from the glass tubes in which cultures were made, which were deeply etched by their action.

In the Rothamsted experiments vetches in a rich garden soil, and lupins in a soil from a field where lupins were growing, did not grow as well as

in a sterile quartz sand inoculated with the microbes contained in a small quantity of soil-extract.

The biological factors concerned in preparing plant food, appear to be quite as important as the chemical composition of soils in promoting plant growth. The cereals with the microbes that find favorable nutritive conditions in the vicinity of their roots, undoubtedly have an influence on the soil that aids in fitting it for the growth of leguminous plants with their symbiotic microbes that appropriate free nitrogen and thus add to the available stores of fertility.

The interdependent relations of soil microbes and plants of different habits of growth, must be recognized as significant factors in vegetable nutrition, and a revision of the popular theories of soil exhaustion and manures is needed from this standpoint. The applications of science to agriculture, so far as field crops are concerned, will be best promoted by investigations relating to the life history of these organisms, and their immediate and remote relations to the roots of plants of different species, and to processes of soil metabolism under different conditions.

In the light of recent experiments the prediction made by Dr. M. T. Masters, that farmers in the future will sow the germs of micro-organisms to increase the productiveness of their soils, does not appear to be a visionary one, and it is possible that the breeding of beneficial microbes may prove to be of as great practical interest to the farmer, as the breeding of yeast now is in the manufacture of beer.

We must not, however, be misled by the plausible inferences that may be made from the evidence presented in regard to this recently discovered source of the nitrogen supply of leguminous plants under special conditions. It is not safe to assume that the nitrogen removed from the soil in crops, and by drainage, or otherwise, is fully restored by corresponding amounts derived from free nitrogen through the agency of microbes, or that this is the sole, or, even the main source of the nitrogen of leguminous crops in average soils.

The Rothamsted experiments show that the previous accumulations of combined nitrogen in the soil must be the source of a large proportion of the nitrogen of leguminous crops, and that the frequent repetition of such crops does not prevent an appreciable diminution of the nitrogen of the surface soil.

The evidence, thus far available, seems to indicate that under ordinary conditions of farm practice the microbes concerned in working up the supplies of combined nitrogen in the soil are quite as important factors in the nutrition of leguminous plants as their symbiotic microbes that make free nitrogen available.

THE ETHICS OF STRIKES. By WM. H. HALE, Ph.D., Brooklyn, N. Y.

[ABSTRACT.]

THE author took the ground that there is a mutuality of obligation between employers and employed, just as in all contracts. Hence employés

have no right to stop work by a concerted signal, especially in large enterprises involving the public comfort and convenience, and that such action might well be made amenable to punishment by law.

THE KANKAKEE PROBLEM. By Prof. J. L. CAMPBELL, Wabash College,
Crawfordsville, Ind.

[ABSTRACT.]

The great Kankakee marsh, which disfigures the northwestern portion of Indiana, embraces nearly half a million of acres. Contrary to the general belief, it is not a low swamp, but a broad valley from one to ten miles in width, with a mean elevation above the sea level of 700 feet, more than 100 feet above Lake Michigan, and 150 feet above the Wabash river at Lafayette. This broad valley is bordered on both sides with banks and hills rising above the marsh ten to sixty feet. This valley or marsh doubtless is the bed of the glacial river which was formed by the melting of the great glacier of this section—miles in width but with shallow depth, and which carried the surplus waters to the southwest down a gentle declivity of one foot to the mile. The present Kankakee river is the most crooked stream in the world—its tortuous course measuring between its source and the western boundary of Indiana nearly 250 miles, and between which points a feasible drainage channel may be constructed less than one hundred miles in length. The surface over which this river flows is a light, sandy loam, devoid of rock throughout its entire length in this state. The crooked river now winding through the marsh is a dynamical problem of easy solution with the elements of slope and soil given. The velocity of flow with the fall of one foot per mile is too great for the stability of the sandy bed, consequently the sand taken up by the current, put by retardation along the borders, would cause the narrowing and deepening of the stream, and a consequent increase of velocity which, in turn, would take up greater quantities of the unstable bed, and these would be deposited in the direction of flow. These sand-bars would divert the channel continually, and, following the line of least resistance, the river would change from straight to crooked, until by increased length and decreased slope, a velocity was attained consistent with permanence of the loose bed over which it flows. The practical angle of repose for the Kankakee, with its present average volume of water, is four inches to the mile.

In the year 1882 the legislature of the State of Indiana ordered a survey of the Kankakee river from South Bend, Ind., to Momence, Ill., with a view to the drainage and recovery of the great marsh. For convenience of reference the following levels, taken from the survey of 1882, are given:

Sea level	0
Lake Michigan	585

Kankakee at South Bend	721
Kankakee at Mud lake	690
Kankakee at English lake	667
Kankakee at State line	624
Kankakee at Bull creek	619
Kankakee at Momence, Ill., below dam	613

The general plan of the work included, first, the construction of a new channel approximately eighty miles long in the state of Indiana for the purpose of securing a deeper channel and increased velocity; second, the digging of a large number of lateral ditches to the improved channel; third, the dredging of portions of the old channel; fourth, removal of the limestone ledge which obstructs the river at Momence, Ill. Since this survey was made no general system of work has been entered upon, but there has been accomplished far more than the public has knowledge of, and the progress of recovery of the marsh has been fully up to the reasonable expectations of the most sanguine advocates of drainage. More than fifty miles of ditches, the larger portion 20 feet wide and 5 feet deep, have been cut with steam dredges and by ordinary digging, and the feasibility of the drainage scheme has been fully established.

The Legislature of 1889 made an appropriation of \$40,000 for the removal of the limestone ledge at Momence, Ill., and a commission was appointed by Governor Hovey to carry out the purposes of this appropriation. In the prosecution of this work the right of way has been secured to the State from the land-owners adjacent to the river, and a careful survey and estimate have been made for the improvement. The improvement proposed includes a channel 7 feet at the deepest point, and continuing down the stream with a slope of 3 inches to the mile, until the present bed of the river is reached. The excavation will be 100 feet in width at the bottom, and 200 feet at the top, for all depths over 5 feet. This is regarded as sufficient to carry off the surplus water and to furnish the needed outlet for the further improvement of the river further up the stream, in the marsh lands of Illinois and Indiana. A delay is now occasioned by the Chicago & Eastern Illinois Railway Company seeking to prevent the opening of the dams at Momence and the cutting of the new channel beneath their right of way. This dispute is between the railroad and the heirs of the Cass estate, from whom a part of the island at Momence was purchased, and will have to be settled by the courts. Much needless alarm has been expressed and useless speculation indulged in by some of the citizens of Illinois as to the effect this improvement in the Kankakee will have upon property at Momence and further down the river. It is needless to say that these forebodings are groundless, except, possibly, the effects which will result from the drainage proper of the Kankakee marshes. It is quite certain that the Kankakee will become a much smaller stream when the swamp lands above cease to be reservoirs of water and are converted into productive farms, so that this stream for water power will be less valuable, just as other streams in the state whose sources were in the elevated swamps have become smaller by the general drainage of the

country. But this result is inevitable, whether the rock obstruction at Momence is removed or not, for this removal, while very desirable, is not absolutely essential to the drainage of the marshes. This entire problem is of the greatest interest to Indiana, and its proper solution involves interests of the greatest value.

CONSTITUTIONALITY OF OUR NATIONAL ECONOMIC POLICY. By CHARLES S. HILL, Washington, D. C.

IT was Madison, it will be remembered, in framing the great compact of indissoluble union in the reorganization of our national government for the improved "welfare, security and prosperity of the people of the United States" who placed the forcible and unquestionable power in our Constitution to legislate for the necessary protection of American industries against foreign competition by the following clause:

"Congress shall have power to lay and collect taxes, duties, imposts, excises; to pay the debts and provide for the common defense and general welfare of the United States; to regulate commerce with foreign nations."

It was unanimously adopted and ordered in the great Continental Convention Sept. 17, 1787, that "as soon as nine (of the thirteen) states shall have ratified this Constitution that the new law should be proclaimed and a new Congress assembled."

Thus was created the economic policy of our country in the above provision.

Madison and all the other framers of the Constitution knew that commerce must be *regulated*; that equal conditions were naturally impossible; and hence that "universal principles" were absurd as an economic policy. The preamble of the second act of Congress under that Constitution contained the following clear and forcible logic:

"Whereas It is necessary for the support of Government, for the discharge of the debts of the United States and for the encouragement and protection of manufacturers, that duties be laid on goods, wares, and merchandise imported."

This measure was also moved by Madison, also urged and signed by President Washington and passed by such a majority of the votes of both houses of Congress that the yeas and nays were not called for in either house.

It was not an original act, but according to Mr. Madison, "its recommendation had been universal." He further said in explanation: "Our situation admitting of no delay, I shall propose such articles (for customs duties) only as are liable to occasion the least delay until a system of permanent duties can be perfected."

But the necessity for this reorganization of our national government was found in the conditions of disordered finance and inequitable laws of commerce of the individual states as well as of national demoralization and ruined credit.

The strongest evidence that Mr. Madison regarded a custom's tariff as practical political economy is in his own words. Speaking of the barrenness of the national treasury and the remedy of the evil, he urged that "a revenue must be obtained, but the system must be such a one that while it secures the object it must not be oppressive to our constituents, and happy it is for us that such a system is within our power; for I apprehend that both these objects may be obtained from an impost on articles imported into the United States."

It has also been shown in foregoing letters of this series:

That a protective policy to our industries was a system universally accepted by the Confederation of States preëxistent to the United States Congress (1789);

That its provision was inserted in our Constitution, and adopted in convention presided over by Washington;

That Madison was not only the writer thereof, but also its earnest advocate and especially of the protective provision for import duty, as quoted above;

That Jefferson, the immortal beacon-light of democratic principles and father of that party, laid down such a principle as the law of the land; and—

That it was not until the interests of the south became single in the production of cotton, and in marketing the same in England, and in banking returns in that country, while the north, by the yearly agitation of the slavery question, alienated those exclusively agricultural states which, in a greatly mistaken principle, blinded her best statesmen, as early as 1824, to the economic interests of the country by the passions of the political antagonism produced.

And to show the fundamental principle of our economic policy, and its constitutionality, the following extracts are herewith quoted in chronological order.

The patriots, for whose injunction upon the American people to preserve inviolate the laws they left us consideration is asked, are Washington, Adams, Jefferson, Madison, Monroe and Jackson. All urged the necessity of protecting and fostering our commerce and navigation, as will be seen by the following extracts.

Washington, in his first message, Jan. 8, 1790, says:

"The advancement of agriculture, commerce, and manufactures by all proper means will not, I trust, need recommendation, but I cannot forbear intimating to you the expediency of giving effectual encouragement as well to the introduction of new and useful inventions from abroad, as to the exertions of skill and genius in producing them at home."

In his message, Dec. 7, 1796, Washington said:

"Ought our country to remain dependent upon foreign supply—precarious, because liable to be interrupted? If the necessary article should in this case cost more in time of peace, will not the security and independence thence arising form an ample compensation?"

This warning was conveyed by Adams in his message of May 16, 1797:

"The commerce of the United States has become an interesting object of attention,

whether we consider it in relation to the wealth and finances or the strength and resources of the Nation. To prevent it from being undermined or destroyed it is essential that it receive an adequate protection. Our agriculture, fisheries, art and manufactures are connected with and dependent upon our commerce. In short, commerce has made this country what it is, and it cannot be destroyed or neglected without involving the people in poverty and distress" . . .

Jefferson said, in his inaugural speech, March 4, 1801:

"I deem the essential principles of our Government . . . commerce and honest friendship with all nations; encouragement of agriculture and of commerce as its handmaid."

In his message, Dec. 15, 1802, he said:

"To cultivate peace and maintain commerce and navigation in all their lawful enterprises . . . and protect the manufactures adapted to our circumstances, are the landmarks by which we are to guide ourselves in all our proceedings."

Again, in his eighth annual message, Nov. 8, 1808, he said:

"We must apply a portion of our industry and capital to internal manufactures and improvements. . . Little doubt remains that the establishment formed and forming will, under the freedom of labor from taxation, under protecting duties and prohibitions, become permanent."

This was about the time that Jefferson introduced his famous "Embargo Act (107)."

Thus we find even prohibition, under some circumstances, a great democratic principle. The plainest expression of his views was written by Jefferson in a letter to Benjamin Austin, of Boston, 1816, in which he said:

"The grand inquiry is, Shall we make our own comforts or go without them, at the will of a foreign nation? He who is against domestic manufactures must be for reducing us either to dependence upon that nation or be clothed in skins and live like wild beasts in dens and caverns. I am proud to say that I am not one of these."

These are strong words and "Jeffersonian principles."

But here is the final answer to all misunderstanding or misrepresentation as to constitutional right, or as to the principle laid down as the true economic system. The quotation is from Jackson's message of Dec. 7, 1830:

"The tariff is objected to by some as unconstitutional. The power to impose duties on imports originally belonged to the several States. The right to adjust these duties, with a view to the encouragement of domestic branches of industry, is so completely identical with that power that it is difficult to suppose the existence of the one without the other. The states have delegated their whole authority over imports to the General Government without limitation or restriction, saving the very inconsiderable reservation relating to their inspection laws. This authority having thus entirely passed from the States, the right to exercise it for the purpose of protection does not exist in them."

Here is a clear reason for the refusal sometimes cited, and of Congress to recognize state rights in individual state tariff laws as prohibited in the following clause of Sec. 9, U. S. Statutes.

"No preference shall be given by any regulation of commerce or revenue to the ports of one State over those of another; nor shall vessels bound to, or from, one State, be obliged to enter, clear, or pay duties in another."

The Constitution further sets forth the key-note and fundamental economic principle of an equitable government, and immortalizes the fore-

sight and discretion of the Fathers of the Republic. See Sec. 10, U. S. Statutes.

"No State shall, without the consent of the Congress, lay any imposts or duties on imports or exports, except what may be absolutely necessary for executing its inspection laws, and the net produce of all duties and imposts, laid by any state on imports or exports, shall be for the use of the Treasury of the United States; and all such laws shall be subject to the revision and control of the Congress."

This is clear prohibition against the intermeddling of state interests with national interests and is the only application or inference that can be drawn. Jackson continues:

"The indispensable power thus surrendered by the States must be within the scope of authority on the subject expressly delegated to Congress. I am confirmed as well by the opinions of Presidents Washington, Jefferson, Madison and Monroe, who have each repeatedly recommended this right under the Constitution, as by the uniform practice of Congress, the continued acquiescence of the States, and the general understanding of the people."

These words of Jackson cannot be answered; they cannot be mistaken in meaning or in defining the conditions of our country, or as to the principles of the fathers who framed our government; they are as forcible and as truthful as was his exposition in his nullification proclamation, two years later (1832), of the true purpose of that agitation — that it was not the nullification of our great economic laws that was aimed at or desired in fact — but nullification of our constitutional alliance; for disunion completely, as was the purpose of secession in 1861.

It is to be hoped that such destruction of our economic reason may not occur again, nor delusive theories be submitted as a party platform to our people. If it is precipitated, South Carolina will stand firm for protection of her rice industries; Louisiana for her sugar product; Georgia and North Carolina for their cotton manufactures; Alabama for her coal and iron resources; and the West, busy and independent in making her own supplies, will, with the rest, form a politico-economic phalanx that will defeat the "glittering generalities" of "free-trade" delusion as effectually as "the fathers of our country" defeated the states separately in the over-zealous desire to duplicate national powers for the purpose of extinguishing their debts by too much protection.

Jefferson and Jackson have recorded themselves perhaps more forcibly than any other of our statesmen.

In his letter (above quoted) Jefferson emphasized his views too plainly to be misunderstood. He wrote as follows:

"Mr. BENJ. AUSTIN, Boston, Mass.:

"You tell me I am quoted by those who wish to continue our dependence on England for manufactures. There was a time when I might have been so quoted with more candor. But within the thirty years which have since elapsed, how are circumstances changed! . . .

"We have experienced what we did not then believe, that there exists both profligacy and power enough to exclude us from the field of interchange with other nations; *that to be independent for the comforts of life we must fabricate them ourselves.*"

And the consistency in economic principle of that sturdy old patriot, hero and economist — Jackson — is shown in the following extracts of

letters, which should live in the memory of our people, especially of those who live in that locality, defended and saved through his heroism, and who admire his principles politically; surely all must admire him more in recalling the evidence of his consistency in blending the political with the economical in principles of national government.

In a spirit of narrow-mindedness at the time that political hatred in the south was growing toward the north, and so-called nullification in reciprocation to the passion of abolitionism, the popularity of General Jackson was developing as a politician to the same degree as he had attained as a hero, and it was attempted to intimidate him as a statesman, and utilize him as an instrument of policy at the sacrifice of his judgment in economy, and of the true interests of our country, as will here be seen:

"WARRENTON, VA., April 21, 1824.

"TO GENERAL ANDREW JACKSON.

"DEAR SIR: Being one of the six members of the Virginia Assembly in caucus last winter who voted for you as a fit and proper person to be supported by the people of the State for the Presidency of the United States, and having since heard that you are in favor of the 'protective-duty policy,' I take the liberty of desiring you to inform me whether you intend voting for the tariff bill now before Congress. I wish to have information on the subject as soon as your convenience will permit, that I may answer the Fredericksburg Committee, who invite my co-operation in getting up a ticket for the hero of New Orleans. In this country you have many friends, and some think your support will be better in Petersburg than in any of the contiguous counties. We are anti-tariff here, and candor requires me to say that should you be the advocate of a measure to which our interest is evidently opposed, the zeal with which you have been hitherto supported will be relaxed.

I am, etc., L. H. COLEMAN."

It was Henry Clay who said he would rather be right than to be President, but it was General Jackson who fired a charge of economic cannister and grape at the man who dared to bribe him with the temptation of that high office and power at the sacrifice of principles and a faithful support of the economic policy founded in the Constitution of our country:

"WASHINGTON CITY, April 26, 1824.

"SIR: I have the honor this day to receive your letter of the 21st instant, and with candor shall reply to it . . . You ask me my opinion on the tariff. I answer that I am in favor of a judicious examination and revision of it; and so far as the tariff before us embraces the design of fostering, protecting and preserving within ourselves the means of national defence and independence, particularly in a state of war, I would advocate and support it. The experience of the late war ought to teach us a lesson, and one never to be forgotten.

"Heaven smiled upon and gave us liberty and independence. That same Providence has blessed us with the means of national independence and national defence. If we omit or refuse to use the gifts which He has extended to us, we deserve not the continuation of His blessings. He has filled our mountains and our plains with minerals, with lead, iron, and copper, and given us a climate and soil for the growing of hemp and wool.

"These being the grand materials of our national defence, they ought to have extended to them adequate and fair protection, that our manufactories and laborers may be placed on a fair competition with those of Europe, and that we may have within our own country a supply of those leading and important articles so essential to war.

"I have presented you my opinions freely, because I am without concealment, and

should indeed despise myself if I could believe myself capable of acquiring the confidence of any by means so ignoble.

I am, sir, very respectfully, your obedient servant,

ANDREW JACKSON."

This letter is only equalled by that of Thomas Jefferson (quoted above), and although both are necessarily given here in excerpts, they should be fully read to be fully appreciated.

The particulars have been detailed in full, in a preceding letter, of the struggle of the new-born States in legislative contention over discussion of an economic policy—fierce almost as the struggle for independence that almost disrupted their union, from 1783 to 1789, under the Old Confederation—until the agreement to settle the question of rates of import duty in convention of specially appointed delegates, and at this convention adopted our present Constitution, and virtually reconstructed our Union under the title of the United States, especially with a view to a successful "regulation of commerce" under the essential agreement of one uniform Tariff.

It is not necessary here to again present the official history that was given from the archives of old records carefully examined in the Department of State, and given in the record of Tariff conditions of 1774-1789. That history can never be eliminated from the annals of our country.

Congress, it has been admitted by all statesmen for the long century of our national existence, has direct and explicit authority, *by the Constitution*, in the very cause of its preparation, therefore, and in its distinct provisions, to regulate our commerce with foreign nations.

The inadequate provisions of Reciprocity Treaties, and the instability of such protection from the changeability of the economic conditions peculiar to every growing country and intelligent community appear, however, remarkable. We have seen our commercial marine, wrenched from us by Treaty stipulations, accepted and inserted by short-sighted diplomatists; we have seen appropriation after appropriation authorized for river and harbor improvement; we have seen yearly provision—although stinted and meanly begrudged by some politicians—for representatives to live abroad, empowered with the functions of Consul and Envoy extraordinary, to watch and protect the interests of our anticipated commerce; and yet, at this advanced period of our national life, the cry is heard in our halls of legislation, and reverberated throughout our country, that—

"*Congress has no right to protect commerce!*"

Was ever a political cry so extremely inconsistent?

Men who loudly boast in Congress of their free love for "free land," "free men," "free trade," and who bargain for their special interest in the annual appropriation bills for buoys and beacons, lighthouses and custom houses, to impress their constituents with an idea of their watchfulness, of their local commercial advancement, are heard to declare, almost in the same breath, and to stultify consistency, by adding—but—

"*Congress has no power to impose impost duties.*"

Impose? What imposition it would be upon us, and how unconstitutional it would be in our statesmen, to enslave us to the tricks of foreign

traders, and to rob us—the former of manufactures—of an equitable chance to develop a home market, and to compete in the world's commerce, for the two-fold benefit of revenue and protection?

If it is "robbery," as absurdly declared by some agents, to enact, under our Constitution, a law for impost duty to protect home trade, it is robbery also and unconstitutional to enact for provision for river and harbor and all coast defence; it is robbery to the industrious American of the spirit of thirst and reward of prosperity.

Our Constitution was not made by partial statesmen. It is simple, clear, and equitable; it is the most scientific, economic instrument ever prepared; it has lasted through many severe assaults and continued sieges of attempts to misconstrue its tenor and power for both political and economic schemes of foreign rivals, but it will stand while the world stands, and cannot be nullified except in the imagination of theorists of special interests.

That the prosperity of the south was regarded by our great men in the earliest period of our Republic as dependent upon a uniform tariff of import duties is emphatically expressed in the following resolution adopted in the House of Delegates of Virginia, Jan'y 21, 1785:

"Resolved, That Edmund Randolph and others be appointed commissioners, who, or any five of whom, shall meet such commissioners as may be appointed by the other States in the Union, at a time and place to be agreed upon, to take into consideration the trade of the United States; to examine the relative situations and trade of the said States; to consider how far a uniform system in their commercial regulations may be necessary to their common interest and their permanent harmony, and to report to the several States such an act relative to this great object."

But to quote the happy words, referring to these facts, of that profound statesman—Webster,—half a century after, will be refreshing to the memory of readers, and satisfactorily pleasant in reading a happy opinion:

"We may look at the debates in all the State conventions, and the expositions of all the greatest men in the country, particularly in Massachusetts and Virginia, the great northern and southern stars, and we shall find it *everywhere held up as the MAIN reason for the adoption of the Constitution*, that it would give the General Government the power to regulate commerce and trade."

Mr. Webster shows also that:

"This power was thus considered established by the framers of the Constitution, and has been steadily recognized by the Government."

He says further, and can words be more emphatic?

"It was distinctly and in terms recognized by the very *first act* laying duties of import. *It pervades the history of our legislation.*"

There never was a doubt of the cause of the reorganization of our Government in framing the Constitution, or of its cementing properties in this very cause. It was to strike at this very cause, as a means of dividing the Union, that the advocates of nullification worked in their political passion in prejudice against the advocates of abolitionism.

"Commerce! Commerce! is the beginning and the end of it," exclaimed Mr. Webster, in a fervent appeal for the preservation of our Union upon the principles in and that suggested our Constitution, for the permanent,

equitable, and remunerative economic policy in protecting American labor and trade.

The industry and commerce of any country can only be preserved by vigilance and judgment in watchfulness of the changing advantages or disadvantages of the principal nations of the world and in wise legislation, according to existing conditions, and not to theories of foreign economists who lived a century ago, like Adam Smith, or to a policy adaptable or acceptable to foreign powers, however fascinating.

But finally, in consideration of the constitutionality of a tariff of import duties, it is necessary to cite the ruling of the highest tribunal of our land, the Supreme Court of the United States, which has made this question *res adjudicata* in the several opinions and decisions recorded whenever and wherever the point has been blended with cases considered by that supreme power. And such decision has been emphatic, distinct, and universally consistent, that it is not only within the power of Congress to make a tariff of import rates both for revenue of our treasury and for the protection of our industries, but also that it is the duty of that national body to look to those economic interests of our country.

"This power," the Supreme Court declared, in the case of *Gibbons vs. Ogden*, "like all others vested in Congress, is complete in itself. It may be exercised to its utmost extent and acknowledge no limitations other than are prescribed in the Constitution." The expression "to its utmost extent" and "no limitation" must doubtless have been unread by some of our statesmen who claim to be legal or constitutional advisers.

But, it may be asked, what "power" is meant by this opinion of the Supreme Court? The words of the court in the quoted case are:

"What is this power? It is the power to regulate—that is, to prescribe the rule by which commerce is to be governed. Now the court asks and answers the question clearly and finally."

Again and again this highest court has been emphatic upon the constitutionality of our national protective policy. And emphatic still, yet, withal, in wisdom and discretion, discriminating between extreme and mediocre measures, the court declares, in the case of the *United States vs. Masagold*, as follows, in the most forcible opinion:

"In Congress, by the Constitution, is vested the power to regulate commerce with foreign nations, and although, at periods of excitement, an application of the terms 'to regulate commerce,' such as would embrace prohibition, may be questioned, yet, since the passage of the embargo and non-intercourse laws and the repeated judicial sanctions which those statutes have received, it can scarcely, at this day, be open to doubt that every subject falling within the legitimate sphere of commercial regulations may be partially or wholly excluded when either measure shall be demanded by the safety or by the important interest of the entire nation."

Here is the question of constitutionality clearly and definitely expounded and settled.

Who are to be the judges of the "important interests of commercial regulation?" Theorists and lawyers, or statesmen, who are business men of every industry?

Yet we hear weekly in Congress from some theoretical statesmen, as

well as from influenced journalists and foreign agents, those old hackney or British "cockney" cries that "a tariff is a tax," "a tariff is barbarous," "robbery," "unlawful," "unjust," "inequitable," when the experience of our fathers in the old Confederation forced them to reorganize their form of government and formulate a constitution providing expressly for such economic policy, when it has been preserved through generations and through political dissensions and conflicts, and when the Supreme Court has again and again maintained that it was just, equitable, and constitutional. Who then is it who cries robbery? and for what motive?

In the language of Webster: "*Can we regard him as a safe counsellor in the affairs of our Government whose thoughts are mainly bent on considering not how the country's (and the people's) interest can be best preserved (and advanced), but how tolerable shall be the conditions of our people when our (industries) shall have been broken up and destroyed*" by being given over to foreign labor, under England's economic policy—"a trick of trade" to inveigle the credulous of other nations—by madness of free-trade theory

"Free trade" is an anomalous term, and means nothing but deception. It is a misnomer. Free trade is chance—lottery. It is fascinating, but disappointing, because it is blind trade or trade with scales. A tariff is the balance in international exchange of commodities. A free-trade essay and a *lottery ticket* are of parallel speculative character and equally fraudulent and condemnable as mail matter.

Congress has no right to tamper with commercial regulations upon theoretical notions, but only upon the advice of a council of all industrial interests which are so interdependent.

But a tariff to be protective must be as correct as the scales in weight.

A tariff cannot be correctly made by politicians or men of accidental power. It can only be done by consultation with those whose practical knowledge qualifies their advice; and, unless such aid is consulted, consequences should not be blamed for conglomerate and inequitable rates in tariff schedules.

A tariff to be just must be based upon all of the following conditions, viz.:

Labor—which embraces wages and living.

Interest—which should be considered in rate as trade advances westward.

Material—which is the chief product.

Supplies—which are the elementary.

Value—which estimates the whole investment—capital and plant.

Taxation—which includes internal revenue and local tax.

Freight—which depends upon competition in carrying trade.

Measurement—which, with weight, is an item of cost.

Insurance—which must be calculated in total costs.

Exchange—which is a British monopoly of the world in finance.

To properly study and ascertain these conditions and their relations and effect upon our industries it is necessary to obtain the latest data, which the manufacturer alone can give.

The tariff is not of individual benefit; it is a protection to all interests, as shown in other letters of this series; but a tariff must be made upon just and correct estimate of equity and harmony for each other's interests and by making mutual concessions.

This has been and is said to be impossible, but it is not impossible. It has, however, never been accomplished but once in recent years, and that was by the Metropolitan Industrial League of New York, in 1882, which presented to Congress the most equitable and harmonious tariff ever prepared. (See H. R. Bill 7855, 47th Cong., 2d sess.)

The title of the Tariff Act of July 4, 1789—the first under our reorganized government—read:

"An act for the discharge of the debts of the United States and the encouragement and protection of manufacturers."

The West and South are far more benefited by the tariff than the North-east, because of the rate of interest and advanced condition of industries. These points have been fully shown in preceding letters, and the clear, emphatic opinions of Jefferson and Madison quoted *verbatim*, but I may here quote from my Letter No. 28:

"As we have seen from the official record of the old journals of Congress that the new Congress and the Constitution were created for this very purpose, it is very natural that not one word of objection can be found recorded "against the *constitutionality* of such protective policy," and that the debate thereupon was entirely as to the *rate of duty* for each article; and although Mr. Madison's bill was delayed in enactment, enlarged in enumeration, and increased in rates of some articles, it was unanimous in its passage as a bill, successful in its working as an economical law, and popular as a policy of political economy.

"There is no mention made by anybody about "*unconstitutionality*," for the origin and object of the Constitution were fresh and understood!"

The Supreme Court of the United States having iterated and reiterated and sealed this distinct provision, as we have seen by its legal decisions, the people of the North, South, East and West at all times will emphatically defend such constitutional right by their seal upon the ballot-box, in their sacred privilege and decision by suffrage, whenever the question is submitted to them point blank, whether protection to all industries, in discretion and discrimination, as the economic policy of our fathers, shall be preserved.

We have lived through political strife in attempts to destroy our Constitution. May our country be always blessed with economic harmony in veneration for its wise provision for an economic policy in prosperity of peace and thirst of industry, even unto eternity.

HOW SHALL WE UTILIZE VAGRANT CHILDREN? By LAURA OSBORNE TAL-BOTT, Washington, D. C.

[ABSTRACT.]

IN undertaking any important work in mechanics, it is customary to seek security at the foundation.

A bridge would have but little utility without careful mathematical measurements, with choice of good workmen by the engineer in charge of the construction of the foundation.

Human life and character, however humble, enter vitally into the very life of our nation. In economic subjects, involving the happiness or misery of millions of human beings, very little treatment of a scientific character is given to the early training of vagrant and neglected children.

Our civilization shows this at every turn, and it is most evident that upon no subject involving results of such immense importance to civilization does mankind pursue such a fallacious course as in the neglect of children.

The greater number of children come into the world diseased either in mind or body, which with added neglect permits them to grow up in many cases to become burdens upon society.

As American citizens, no doubt, we are able to give our own estimates as to the rate of increase of population in the United States, but we are often helped by knowing how we are regarded by lookers-on.

Carlyle tells us that "Americans double their number every twenty years," and John Fiske makes this statement a basis for his calculations that at the close of the twentieth century we shall have reached the stupendous figure of fifteen hundred millions.

With this rate of increase and the fact that large masses of children are growing up in ignorance and vice to furnish criminals to become burdens upon our tax-paying communities, is it not time to consider and to reflect upon the question from an economical standpoint, how this troublesome element in our country is to be at once benefited and utilized?

The present system of public schools does not reach this class for many reasons; a very important one is, that no child is permitted to attend a public school until six years of age. It is well known that a child gains more knowledge through its perceptive faculties during the first five years of its life than during the same length of time at any later period. What if the best teachers were placed over each and every vagrant child in kindergartens or other training schools, where every immoral tendency could be eradicated, if possible, would these little waifs grow up to fill our jails, asylums and almshouses?

Is it not preposterous that such an immense waste of ill-directed human power should be permitted to go on amidst our boasted intelligence, energy and wisdom?

In the city of Washington, no official enumeration of the children has ever been made, and therefore it is impossible to ascertain the exact number who never attend school. "Any one who runs may read," however, for the gamin of the streets of Washington are numbered by the police at many thousands.

Hon. Wm. T. Harris, commissioner of education, tells us that the gamin of the street cease developing by the time they have reached the age of twelve years and become dwarfed mentally and morally.

It would be idle to refer to such stock illustrations of the increase of

vagrancy and crime as in the Juke family and others, but although these startling facts are well known, our people seem to be in a state of apathy upon the subject which is truly amazing, when we consider the rapidity with which our population increases and the potent factors children become for good or evil in our civilization.

Is it any wonder that our press is daily filled with more annals of crime than anything else; and when we consider that the majority rule in this country, should we not reflect upon the majority of citizens in fifty years to come.

Very little, if any, preventive work is attempted or accomplished to save neglected children in any well organized work, save in the state school at Coldwater, Mich. Is it not a proper subject for legislation to consider how best to utilize the energies of vagrant children?

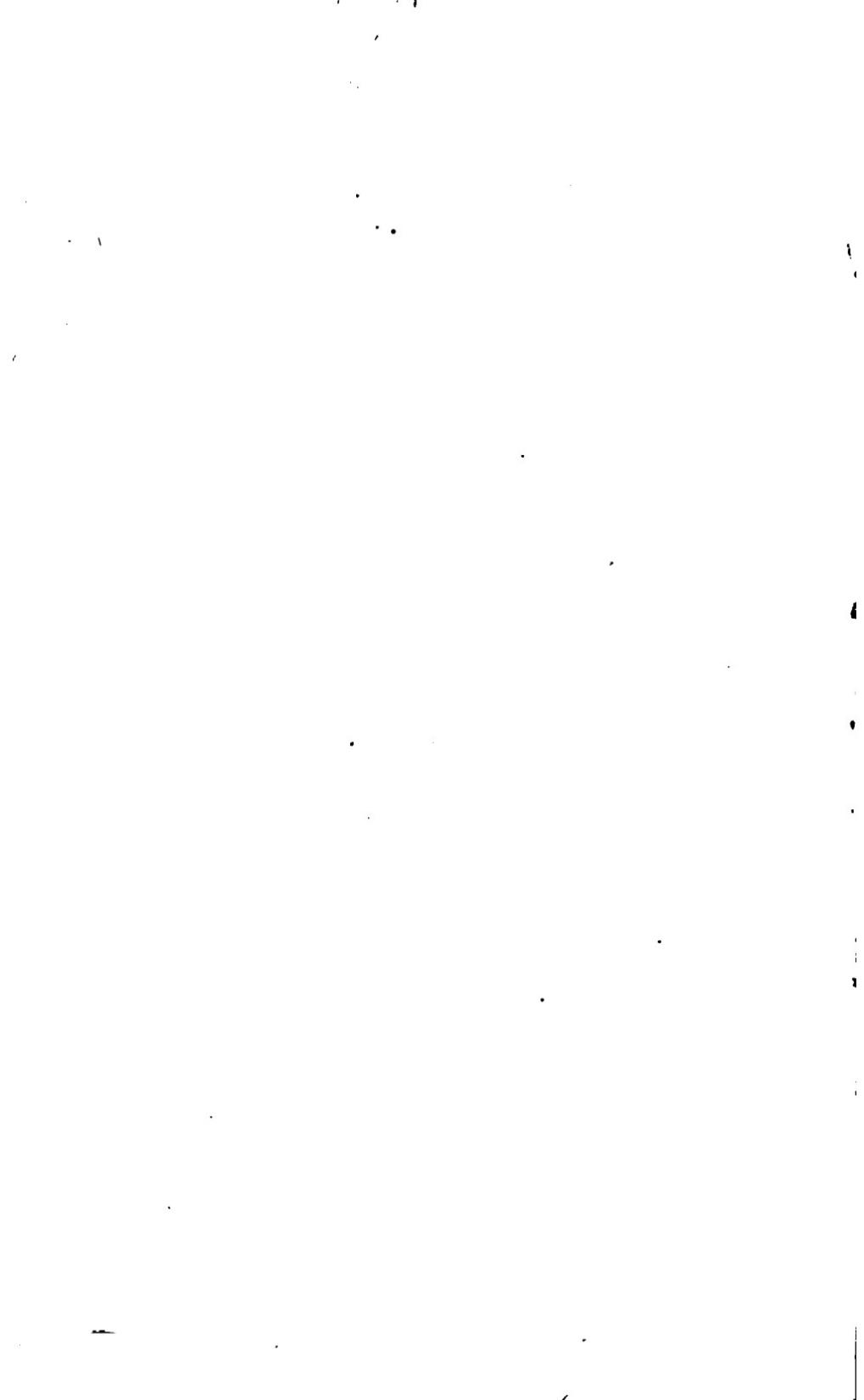
Could our legislators take a *statesman-like* view of this subject of little children and establish training schools of the best kind, according to physiological and psychological principles, posterity might well arise and bless the names of those who had assisted materially in removing ignorance and vice from our land.

AMERICAN MONEY, PAST AND PRESENT. By S. DANA HORTON, Washington, D. C.

INSTRUMENTS OF VALUATION, OR THE NATURE OF MONEY UNITS. By S. DANA HORTON, Washington, D. C.

MUNICIPAL CORPORATIONS AND NATURAL GAS SUPPLY. By PROF. EDWARD ORTON, Columbus, Ohio.

A NEW SYSTEM FOR IMPROVING THE DRAINAGE AND PREVENTING DAMAGE BY THE FLOODS OF THE MISSISSIPPI RIVER. By GEORGE W. HOLLEY, Ithaca, N. Y.



EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

THE thirty-ninth meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE was called to order on WEDNESDAY, AUGUST 20, 1890, at 10.20 A. M., in the Hall of Representatives, State Capitol, Indianapolis, Indiana, by the retiring President, Prof. T. C. MENDENHALL of Washington. The proceedings were opened with prayer by the Rev. CARMI VAN ANDA, D.D.

In resigning the chair to the President-elect, Dr. GEORGE LINCOLN GOODALE of Cambridge, Professor MENDENHALL referred to the meeting in Indianapolis nineteen years ago, presided over by Professor Asa Gray of Harvard, and to the fact that Dr. Goodale, the present President, was successor to Professor Gray at Harvard.

Dr. GOODALE replied briefly on assuming the chair, and said, to correct a misapprehension as to his being the successor of Professor Gray, that he was but one of four men who had taken up the work carried on by Professor Gray.

Dr. GOODALE said of scientific research in general there had been a transition from general to special studies, and this Association served as a trunk of the great body of scientists, the many sections corresponding to the branches. At these meetings specialists could enjoy meeting face to face, and the migratory character of the organization prevented it becoming provincial.

Dr. GEORGE W. SLOAN, Chairman of the Local Committee, then introduced Lieutenant-Governor IRA J. CHASE who, in the absence of the Governor, welcomed the Association on behalf of the State, in the following words:

Mr. President, and Members of the Association for the Advancement of Science:—It affords me inexpressible pleasure to offer to this honorable and justly renowned Association a more than royal welcome to Indiana.

No state in this Union can appreciate to a greater degree the results of your patient investigations nor rejoice more sincerely over your successes.

The descendants of the hardy race who were called upon to subdue the dense forests which once covered our domain, have learned from them how to labor, and how in patience to wait for results.

Be assured, Sir, that we shall not become restive while you are self-

possessed, in efforts to solve the problems that are so full of promise to mankind.

The area of our state reaches nearly to 36,000 square miles. The fertility of the soil cannot be excelled. We dig for gold, silver, iron and coal, and the labor brings its reward. Even diamonds of rare beauty are often found. Our mineral waters are well distributed, and are as famous for their medicinal properties as they are for their copious flow.

Wyandotte cave, as a curiosity, bids fair to rival in size and beauty that of our sister state of Kentucky. The coal fields of the state have 6,000 miles frontage with a capacity of 3,000,000 tons annually.

Thirty-four counties of the ninety-two have free flowing wells of natural gas, some 500 in number, with a daily flow of 1,000,000,000 cubic feet of gas. It is estimated that 20,000 cubic feet is equal to one ton of coal for heating purposes. It is said that the unexpected sometimes if not always happens. Should the sittings of this body be marred by any extended unexpected silence, we will turn on these five hundred wells of gas for your delectation, as the only possible makeshift for the interim.

The building stone of Indiana is inexhaustible and without a rival. For beauty and durability we ask you to carefully examine the building in which you are to find a temporary home, and the great blocks now being placed in the monument hard by, which is being erected to the memory of the Union soldiers and sailors of Indiana who freely offered their lives for her honor and perpetuity. A state, ladies and gentlemen, that could send into the field, as a soldier, about one in seven of her population to defend her homes and flag will not, cannot fail to hail with delight, the coming of this distinguished Association and honor its membership during its sessions with "signs and tokens" that shall cause you to feel that you are not so much our guests, as you are members of the great and "good" Hoosier family.

This mission of yours is in the interest of peace, enlightenment, happiness, and good will to all mankind. Thrice welcome.

Though we have been in the sisterhood of states but seventy-four years, we have been compelled by the stern laws of necessity to remove great mountains of difficulty that stood in the way of our progress and advancement in civilization. We have not failed, while removing successfully these barriers, to produce and develop brain material of a high order. Here I can only start the fire. It will never do to fan the flame on an occasion of this character. More than two hundred authors have published their productions, reaching up to fifteen hundred volumes covering the various phases of literature and many of the sciences. It is not too much to say that not only have these fields of thought been carefully explored but many of them have been well cultivated.

A native Hoosier has accomplished—to speak after the manner of men—the impossible. Here each man and each woman must stand or fall according to merit. Self-reliance is demanded of all who claim recognition from the public. It was almost universally believed by those well qualified to judge on such matters, that Uncle Tom's Cabin would never be rivalled

in the number of editions sold. In the race of book-selling, "Ben-Hur" has fairly distanced the deservedly popular work of Mrs. Harriet Beecher Stowe, though its first edition is of recent date.

Nor is this all. Our Hoosier is scientific if he is anything. The field of literature does not engross all his time or thought. He has taken a hand with the great inventors of the age. He believes that he has wrought out that which will revolutionize the railway building of the world. In any event it will be a "tie."

General Lew Wallace is distinguished as a patriot, also, having served his country in two wars. A gentleman of wide learning, a diplomat of the first rank, honored as a statesman and well beloved by us all as a citizen.

Maurice Thompson is another Hoosier whose rank as a writer is among the first in the land. His very prose is poetry and his poetry is all song. His scientific attainments have long since been recognized as belonging to a high order. His various publications have reached the marvellous sale of 500,000 volumes.

Edward Eggleston was born in the historic town of Vevay. There he commenced his school life in the little brick building now used as a dwelling. Here lived many of the men and women so uniquely described in his earlier works, which gave him notoriety. It is but just to say, however, that we have never felt flattered by the somewhat highly colored "Hoosier Schoolmaster."

Not one of you but have heard of our James Whitcomb Riley, distinctively known as the "Hoosier Poet" far and wide. He is the father of a large family of the brightest and most sparkling dialect poems ever written. He is, as he deserves to be, a great favorite with us. He unites in the greeting we give you, while all nature is still dressed in her livery of green or

"When the frost is on the punkin,
And the fodder's in the shock."

Col. John Hay is to Indiana born, and has contributed much to the preservation of the early dialect of the west, with Eggleston and Riley. His part taken in producing the great History of Abraham Lincoln is well known and is in every way creditable.

John Clark Ridpath, the successful teacher, the entertaining lecturer and voluminous writer, is another Hoosier who has won laurels for himself and his state. He richly deserves the fame accorded him. The sales of his histories are perhaps without a parallel in their line in this country, as no less than 60,000 sets of his History of the World have been sold within a brief period of time.

Col. H. B. Carrington, though not a native-born citizen of Indiana, has taught successfully in college and written widely on various subjects. He is well known as a famous organizer of men, a brave leader in battle, distinguished as a teacher and scholar. His "Battles of the American Revolution" accompanied by forty maps drawn by his own hand, speak in high terms of the genius and industry of our honored citizen.

On Indian Wars our accomplished State Librarian has conquered the field. J. P. Dunn is authority on this subject. Though a young man, his energy and industry make it safe to call him a rising star in literary work.

The venerable judge as well as the learned jurist, Horace P. Biddle, has found recognition in other lines of thought than that of the law. He has long been known as a graceful writer of verse. From the days of Pythagoras to this hour the "Musical scale" has given trouble about weighing properly, somewhere between the first and the eighth note. Pythagoras was no better than any other of the Greeks who stole all they knew from the Egyptians. Our author is quite original and there are many well qualified people in this country and Germany competent to judge on this intricate subject, who believe that Judge Biddle's production on the Musical Scale will long remain the standard work in the settlement of this vexed question of almost three thousand years standing.

Had Forceythe Wilson never written anything but "The Old Sergeant" it would give him an honorable position among the song writers of the country.

Mrs. Julia Dumont, Eggleston's first teacher, was a writer of such force that her productions won her many a prize. Her poems are thoughtful and as fragrant as apple blossoms. Eggleston accords her great honor.

But here is Mrs. Sarah T. Bolton and Mrs. D. M. Jordan, whom many of you know.

Mary Hartwell Catherwood brought forth "Romance of Dollard" and "The Story of Tanti."

Who of you have never heard of Cincinnatus Hiner (Joaquin) Miller? He was born up here on the Wabash.

Mrs. Rose Hartwick Thorpe was born in Mishawaka. "Curfew shall not Ring To-night" was laid by to ripen for a year before it saw light through the press. The early struggles of this lady are the very essence of romance.

In the extreme southwest of Indiana lies the veritable Posey county. It is one of the richest and most beautiful sections of the state. In the northwestern portion of this county is situated the quiet, unpretentious town of New Harmony. It was founded by Robert Owen of Lanark, Scotland, a gentleman of great learning and wealth. Here he and his three illustrious sons, Robert Dale, David Dale, and Richard, made their home. The influence of these men will live in generations to come. Robert made the purchase of 20,000 acres of land when the state was in its eighth year.

Robert Dale Owen was possessed of great learning and was all his life a prolific writer. In 1835 he served in the State legislature and to him more than to any one man is due the laying of the foundation for our princely educational fund for common schools. In 1844 he introduced a joint resolution in Congress which became the basis for the settlement of the northwestern boundary question which was adjusted in 1846. In 1845 he introduced the bill under which the Smithsonian Institute was organized and was chairman of the select committee on that subject. John Quincy

Adams was a colleague who had failed in two attempts to gain the consent of Congress for the same purpose. In 1850 he was a member of the Constitutional Convention of Indiana to remodel the constitution of 1816. In 1851 he drew up the bill which became a law, securing to women independent property rights. As minister abroad and as a diplomat he was satisfactory to the government. Secretary Chase says his letter to Mr. Lincoln on the subject of emancipation, had "more effect on the president to make his proclamation than all the other communications combined."

David Dale was employed by this state in 1837 to make a geological reconnaissance. In 1839 he was employed by the United States Government, the first undoubtedly so appointed, to make a minute investigation of the mineral lands of Iowa. He did the same for Wisconsin and Illinois. In 1849 the National government employed him to conduct the survey of Minnesota, then a territory, and appropriated \$40,000 for that purpose. He performed valuable service in the territory of Nebraska. From 1854 to 1857 he was state geologist for Kentucky. In 1858 performed same duty for Arkansas. In 1859 and 1860 he was state geologist again for Indiana, his adopted state. As an artist, chemist and geologist he is entitled to the distinction accorded him. At his death, the state purchased his specimens for \$20,000 for her university. Edward T. Cox, so well known to you as a geologist, was his pupil and companion from his youth to the day of David's death.

Richard Owen was a patriot and scientist. He served as a captain in the Mexican war under General Taylor, and was commissioned Colonel of the 60th Indiana Vol. in the war for the Union. He assisted his brother David in his survey of Minnesota and explored alone the north shore of Lake Superior. He was appointed in 1859 assistant state geologist for Indiana and made a careful survey of the state. In 1864 he was elected to the chair of natural sciences in the State University, which he filled with distinction for fifteen years.

One of the beautiful new buildings of the University has been named in his honor. This distinguished scholar was as unassuming as he was learned and a devoted Christian gentleman. His contributions to geological knowledge of Indiana, Minnesota, New Mexico, Arizona and North Carolina are well known.

To New Harmony the great French naturalist, LeSueur (who with Peron explored the Australian coast) came to gather some fruit from earnest lives.

Thomas Say, Esq., founder of the Academy of Sciences of Philadelphia, honored this seat of learning with his presence and was himself honored thereby. Hither came Joseph Neef, friend and companion of Pestalozzi.

The world-famed Sir Charles Lyell, visited this Mecca of science and scientific men for the purpose of making special geological surveys. It was, as you must know, the only headquarters for eminent geologists from 1837 to 1881, west of the Alleghanies.

The only lady in the United States who was thought worthy of special mention as a musical composer in that great work, "The Musical Diction-

ary," or "One Hundred Years of Music in America," was Mrs. Constance Faunt Le Roy Runcie. Her grandmother twice refused the hand of Washington, who sought her in marriage. She is a granddaughter of Robert Owen and was born in this city. She began her musical compositions at the early age of seven years. She has devoted her life to the welfare and happiness of others and is a highly cultured, educated Christian lady.

Dr. Daniel Kirkwood, so well known as an educator, has read the heavens over and has told the world what he has seen.

Prof. John M. Coulter, educated within the state, has devoted his life to a study of the "lilles" to see how they grow and we are in possession of his wealth of learning on the subject of botany.

Prof. John Collett, by birth and education a Hoosier, has become eminent as a geologist and has collected for himself the "testimony of the rocks" and we have come into the possession and enjoyment of his arduous labors.

Dr. D. S. Jordan, the honored president of the State University, is the prince of Ichthyologists. He has fished the waters from the Polar to the southern seas. In the classics a graduate of Cornell; of medicine, Indianapolis. His life as a teacher, author and investigator belongs to Indiana.

I regret the absence of the honored president of the Fly Fisherman's Club of this city, who lately flew to the east. But the several vice presidents of that ancient and honorable institution will stand around the corridors to await your bidding, with their hands flled with angleworms or with buckets of minnows to escort such ichthyologists as may desire to conduct original explorations and investigations to such creeks and rivers as said ichthyologists may select. The only condition being that of providing each for himself his own locomotion.

Prof. O. P. Hay of Butler University is good authority on all that creeps or jumps, belonging to the slimy, wretched reptile creation, of which I dare not speak particularly.

As to our manufactories, we have the largest plate-glass, wagon and plough works in the world. The others, embracing almost every article of trade and commerce, are too numerous to mention.

I must be permitted to say a word in behalf of the noble army of ministers of Indiana. The name of those who deserve special mention is legion. Many of the most active educators and diligent scientists of our state have devoted long lives in proclaiming the sweet and beautiful truths of Christianity. They believe with their pilgrim fathers that to reach the highest intellectual attainment the meetinghouse and the schoolhouse must be built side by side.

Will you, my auditors, kindly suffer a moment longer while I speak modestly of our statesmen. Since we have been giving respectful attention to tree culture in Indiana, we have forbidden the girdling of presidential timber which grows quite generously in this rich soil. Our judges, representatives, governors, senators, vice-presidents and president—I speak now very modestly—are in the van of the long procession of eminent men in our country.

Within a radius of seventy-five miles from where you are sitting, are eleven institutions of learning, the majority of which take high rank in the character of work performed in preparing those under their charge for the duties and obligations of life.

This, my learned hearers, is only a humble and unpretentious preface to the many good things that may be said of the State that now offers you its hospitality.

Permit me then, Mr. President, the pleasure of saying that as long as you choose to remain among us the State is yours, and I hereby deliver the goods.

The HON. THOMAS L. SULLIVAN, Mayor of Indianapolis, then welcomed the association on behalf of the City as follows:

Members of the Association for the Advancement of Science:

The city of Indianapolis extends to you a most hearty welcome. Many of you have come a long journey in order that you may meet with your brethren, and we most sincerely hope that you will in no respect be disappointed in any expectation that brings you here.

I can assure you the citizens of Indianapolis appreciate the fact that this is the second visit of your society. We know that nineteen years ago you did hold a meeting in this city, and we are grateful to you for the compliment you have paid us in choosing to come here again. You will find a great difference between the Indianapolis of 1871 and the Indianapolis of 1890, but you will recognize the same honest, hearty welcome as that which you received nineteen years ago.

We will show you the chief city of Indiana, situated in the centre of this great State; situated also in the centre, or very nearly in the centre, of the population of the United States; a city with railroads so numerous that fifteen completed lines extend in every direction, over which does pass and repass the commerce of this country. We will show you a city situated in a vast region of as rich agricultural land as any on this earth.

Indianapolis is also a manufacturing city, with a thousand manufacturing establishments producing numerous articles, some of which we hope will prove of interest to you.

We will show you a city into which the energy and enterprise of its citizens have conducted the cheapest fuel on earth from the reservoirs in which nature has hidden it.

Laid out so as to afford the greatest amount of pure air and consequently the greatest amount of good health to its citizens, the broad streets of our city, lined with innumerable shade trees, make Indianapolis a vast park.

In 1871, when you were here, we had a city of about 48,000 people; now, when you come again, we show a city of 125,000, with the suburbs. Above all, we will show you a city of homes. I suppose there is no place where 125,000 people dwell that so many live in homes which they themselves own. There can be but little danger of riot or serious municipal disturbance here. It seems quite impossible that we should ever have the

trouble which did rack the city of Pittsburg a few years ago. Building associations have enabled all classes of citizens to have such a proprietary interest in the roof that covers their head that in time of peril, from all classes would spring active, personally interested conservators of the peace.

It is not my purpose to enumerate the distinctive features of this goodly city of Indiana. I only desire to say that whatever we have of interest or that is worth seeing is entirely at your disposal.

We realize that we have to-day within our borders representatives of the scientific intelligence of this generation.

We recognize the fact that you are the gentlemen whose business it is to uncover that which nature has hidden, and to mold and fashion it to the needs and comforts of mankind. It is because of such men as you that miracles have ceased to fill us with wonder, and the seemingly impossible has become an every-day occurrence.

It is because of such men as you that the child of this day does enjoy as a matter of course, without surprise, that which but a short time ago would have filled the sage with wonder and awe.

We may not be able to entertain you as we would like, but we are able to extend to you an earnest and hearty welcome, with every confidence in your ability to entertain not only yourselves, but us also, if we do but give you the opportunity.

Permit me in addition to the welcome which I bring you to express the hope that the result of this meeting may in all respects be as beneficial as the most sanguine of you could desire, and when it is over and you have returned to your respective homes and once more taken up the active work of your thoughtful lives, may you look back with pleasure and satisfaction to the meeting which you did hold in the city of Indianapolis in August, 1890.

Replying to these addresses of welcome, President GOODALE said :

It is difficult, if not impossible, to frame an adequate reply to your warm greetings. From the Citizens we have received a generous welcome, from the Mayor the keys and freedom of the city and from His Excellency, the Lieutenant Governor, a charge which I must turn over to our Permanent Secretary, as I do not feel competent to take the entire charge of the state of Indiana during this week in connection with my duties to the Association. Be sure we take your words of greeting as you have uttered them. The question comes next, what has the Association to render in return? I am sure every member will agree with me that all our Association can carry into any community is its stimulating influence, and that is felt in all directions. I can say certainly that it is not unlikely we shall not only look back with pleasure upon the meeting we hold here, but forward with pleasurable anticipation for another score of years when we hope for as warm a welcome as we now receive.

The GENERAL SECRETARY announced that 161 papers had been entered for reading. He also read the following letter :

University of Toronto, Oct. 28, 1889.

PROF. F. W. PUTNAM,
PERMANENT SECRETARY,
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SIR:

I have the honor to forward you engrossed copy of the address to the President and Members of the American Association by the Vice-Chancellor of the University of Toronto at the meeting held in Toronto last August.

Your obedient servant,

H. H. LANGTON,

Registrar.

The PERMANENT SECRETARY stated that the engrossed copy of the address referred to was preserved in the office of the Association, Salem, and told how the University of Toronto had suffered great losses by fire since the Association had received hospitality under its roof, and suggested that each member of the Association could best show his appreciation of the kindness received from their Canadian brethren by contributing one or more volumes to their library, or specimens to their collections, to aid in restoring that which had been lost by fire.

The GENERAL SECRETARY read the following resolution of thanks addressed to the Chancellor and authorities of the University and recommended by the COUNCIL to the Association for their action:—

This being the first meeting of the Council since the receipt of the engrossed copy of the address of welcome to the Association in Toronto, in August last, by the Vice-Chancellor of the University of Toronto, the following resolutions are recommended by the COUNCIL.

Resolved, That the American Association for the Advancement of Science hereby acknowledges with much pleasure the receipt of the beautiful copy of the address of welcome to the Association on the part of the authorities of the University of Toronto in August, 1889.

Resolved, That the PERMANENT SECRETARY cause this address to be framed and hung in the office of the Association at Salem, Mass., as a pleasant reminder of the generous hospitality extended to the members of the Association during the successful meeting in Toronto, in 1889, as well as in recognition of the continental character of the Association, which is intended to be American in the widest acceptation of the term.

Resolved, That the members of the Association extend to the authorities of the University of Toronto their heartfelt sympathy for the great loss sustained by that University when, on the evening of Feb. 14, 1890, the magnificent University building with its contents was so nearly destroyed by fire; and that they express the hope that the friends of education everywhere will extend to the University such substantial aid in restoring and furnishing the building that it may again open its doors for

the culture of youth and the encouragement and development of scientific research.

The resolutions were unanimously adopted.

The GENERAL SECRETARY read the following letter and circular:—

*Australasian Association for the Advancement of Science,
Canterbury College, Christchurch, N. Z.,
April 18, 1890.*

DEAR SIR :

The Council of this Association invites all members of the American Association to its next meeting to be held in Christchurch, N. Z., in Jan., 1891.

I do not know whether you would be able to obtain reduction in the railway fares to San Francisco; but if I were to get a letter from you saying that it was probable that several of your members would attend, I think that I could get a reduction in the passage from San Francisco to New Zealand. I can already promise that all members of your association will be allowed to travel over the New Zealand Government railways (1700 miles) at half fare during the months of January and February, 1891.

I will send you presently some circulars for distribution at your next meeting; and if I receive an encouraging reply from you I will send you some certificates for issue to intending visitors which will give them all the privilege of members of our association.

I should be much obliged to you if you would tell me when and where your next meeting is; and also if you would send me a copy of your rules.

Yours truly,

F. W. HUTTON,

Hon. Sec. for New Zealand.

Prof. F. W. PUTNAM.

*Australasian Association for the Advancement of Science,
Canterbury College, Christchurch, N. Z.,
March 31, 1890.*

DEAR SIR :

The objects of this Association are to give a stronger impulse and a more systematic direction to scientific inquiry, to promote the intercourse of those who cultivate science in different parts of the Australasian Colonies with one another, to obtain more general attention to the objects of science, and a removal of any disadvantages of a public kind which may impede its progress.

The third general meeting of the Association will be held in Christchurch, commencing on Thursday, 15th January, 1891, under the presidency of Sir James Hector, F. R. S., and members will obtain special advantages for travelling through the colony.

The annual subscription is £1, and ladies are eligible for membership.

Please fill up the enclosed form and send it to one of the Hon. Secretaries in the event of your deciding to join the Association.

Yours truly,

F. W. HUTTON,

Hon. Sec. for New Zealand.

The GENERAL SECRETARY stated that President Goodale being about to visit Australia had been designated by the COUNCIL to represent the Association at the meeting to be held at Christchurch, New Zealand.

The PERMANENT SECRETARY presented comparative statistics showing that whereas the Association had but six hundred and sixty-eight members when it met at Indianapolis, in 1871, it now numbers two thousand and ninety-nine, and up to 11 o'clock two hundred and nineteen of the number were registered as present. He then read his cash account for the year (as printed in this volume).

He also read abstracts from a letter from Prof. JAMES LOUDON, of Toronto, the Secretary of the Council, who was detained at home by sickness in his family, and he stated that Prof. HARVEY W. WILEY had been elected Secretary of the Council to fill the vacancy.

The Secretary of the Local Committee, Mr. ALFRED F. POTTS, announced the following entertainments: A reception to the Ladies of the Association and of the Local Committee by Mrs. T. L. Sullivan, at Woodruff Place from 4 to 7 P. M. A reception by Mr. and Mrs. Jacobs, at the Institution for the Blind, on Wednesday evening, after the address of the Retiring President.

A garden party at Woodruff Place, on Thursday, at which General LEW WALLACE will deliver an address of welcome at 8.30 P. M.

He called attention to the lecture on electricity by Prof. LEO MEERS, on Monday evening, at Plymouth Church, and to a lecture by Rev. Dr. HOVEY, upon the Wyandotte, Marengo and Mammoth Caves, on Friday evening, in the same hall.

He further announced details of an excursion through the gas-belt of Indiana, on Saturday. On Friday afternoon the Citizens' Street Car Co., offered a complimentary ride to Fairview. He also announced an exhibition of natural gas at 7.30 P. M., before the evening lecture on Monday; the gas will be under four pounds pressure instead of eight ounces as is customary. He gave notice of an excursion to Mammoth Cave, on Wednesday, under the guidance of Rev. Dr. Hovey.

President GOODALE then announced the hours of meetings recommended by the Council. They were adopted and the General Session adjourned.

EIGHT P. M. SAME DAY. At a General Session in Plymouth Church, President GOODALE in the chair, the retiring president Prof. T. C. MENDENHALL, delivered his address [given in full in this volume].

The GENERAL SECRETARY received from the Secretaries of the Sections the reports of organization of the Sections. [These are printed at the beginning of each section in this volume.]

In Section B, Dr. ELROY M. AVERY was elected Secretary to fill the vacancy caused by the absence of Prof. W. LE CONTE STEVENS.

In Section D, Dr. THOMAS GRAY was elected Secretary to fill the vacancy caused by the absence of Mr. M. E. COOLEY. This section did not complete its organization until Thursday.

Section H did not complete its organization until Thursday.

In Section I, Dr. B. E. FERNOW was elected Secretary to fill the vacancy caused by the absence of Mr. S. DANA HORTON.

THURSDAY, AUGUST 21, 1890, Hall of Representatives, State Capitol, 10 a. m. President GOODALE in the chair.

The GENERAL SECRETARY read the following invitation.

*De Pauw University,
Greencastle, Ind., Aug. 18, 1890.*

PROF. F. W. PUTNAM,

PERMANENT SECRETARY, A. A. A. S.

MY DEAR SIR:

On behalf of the Trustees and Faculty of De Pauw University, I hereby extend a cordial invitation to the Association or to any of its members to visit our institution and inspect our equipments. A hearty welcome will be given all who may honor us with such a visit.

Very respectfully,
J. P. D. JOHN.

Also the following:

*State Soldiers' and Sailors' Commission.
Indianapolis, Aug. 20, 1890.*

TO THE PRESIDENT OF THE

AMERICAN ASSOCIATION FOR

THE ADVANCEMENT OF SCIENCE.

Sir:

The members of your Association are respectfully invited to visit the Soldiers' and Sailors' Monument in process of construction in Circle Park, before they leave the city. The gates are open until 6 p. m., each day. They can also see the model of the monument at this office, room 51, State House, at any time from 8 a. m. until 6 p. m., until Friday noon.

Yours truly,
GEO. J. LANGSDALE,
President.

The GENERAL SECRETARY announced 218 papers received to date and called for abstracts of some.

The PERMANENT SECRETARY announced 180 members elected to date by the COUNCIL.

The SECRETARY OF THE LOCAL COMMITTEE explained details of pro-

posed excursions and stated that the evening reception would be held in the State Capitol instead of at Woodruff Place, the garden party having been abandoned on account of the rain. Also that General LEW WALLACE would make an address at 8.30 P. M.

The GENERAL SECRETARY announced a meeting of the COUNCIL at 5.30 P. M., in parlor No. 2 of the Denison House.

Adjourned at 10.45 A. M.

FRIDAY, AUGUST 22, 1890. Owing to the departure of Sections A, B, C, and D, for Terre Haute, no general session was held on this day.

MONDAY, AUGUST 25, 1890. Hall of Representatives, State Capitol, 10 A. M. President GOODALE in the chair.

The GENERAL SECRETARY read the following Resolution which had been adopted by Section A, and recommended by the Council:—

Resolved, That a vote of thanks be transmitted to His Excellency Ger-ville Réache, Governor of Cayenne, French Guiana, for his kindness shown to Messrs. Burnham, Schaeberle and Rockwell, members of the eclipse expedition, to observe the eclipse of December 22, 1889, and for his thoughtful efforts to further the work of the expedition which contributed in a large degree to its success.

Adopted.

Also the following preamble and resolution sent to the Council from Section F, and recommended by the COUNCIL:—

The members of Section F, being informed that the valuable collections of the Division of Botany of the U. S. Department of Agriculture are insecure from fire, view this condition with deep apprehension.

Therefore, *Resolved*, That Section F recommend to the Association the passage of a resolution calling the attention of the honorable Secretary of Agriculture and of the Secretary of the Smithsonian Institution to this fact, with the sincere hope that means may be taken to protect this collection of national importance.

Adopted.

Also the following resolution presented to the Council by Section F, and recommended by the COUNCIL:—

The Association is asked by Section F to print in full in the forthcoming volume of Proceedings the series of papers upon "The Geographical Distribution of Plants," read at Indianapolis, by the appointment of the Toronto meeting. The papers bear the Nos. 117-95-50-100-172-101-119.

Adopted.

Also the following Resolution:—

Resolved, That the American Association for the Advancement of Science accept the gift of \$400 from the Local Committee of the Toronto Meeting of 1889, as an addition to the Research Fund of the Association.

Resolved, That in accepting this gift we recognize again the generous

spirit which characterized the reception and entertainment of the members of the Association by the citizens of Toronto, and that we cordially thank the Committee for this further expression of good will which, we trust, will ever continue between the two countries.

Adopted.

Also the following resolution :—

Resolved, That the American Association for the Advancement of Science desires respectfully to call the attention of the United States Congress, in both branches, to the favorable consideration of the introduction into the tariff measures now pending, of a statement of all items of weight or measure in terms of the metric, as well as of the ordinary, system.

That the Association also most earnestly indorses the resolution already introduced, and now awaiting the action of Congress, recommended by the Pan-American Congress, providing that the metric system be exclusively used in the Custom Houses of the United States after July 1, 1891.

That the said measures will constitute a powerful auxiliary in familiarizing the people with the use of the metric system, and in reinforcing the previous efforts in that direction so favorably regarded by previous Congresses.

That the Association feels that in these recommendations it has the cordial support of intelligent and educated men in all portions of the Union, irrespective of political party or opinion.

That a copy of these resolutions be forwarded to the President of the Senate and the Speaker of the House, the Chairman of the Finance Committee and the Chairman of the Committee of Ways and Means.

Adopted.

Also the following report of a Committee of the COUNCIL on Foreign Membership :

Your Committee, appointed to consider the subject of foreign memberships, respectfully recommends the adoption of the following resolutions, by the COUNCIL :—

Resolved, First, That properly accredited members of all National Associations for the Advancement of Science attending a meeting of the American Association for the Advancement of Science shall be entitled to register without fee as members for the current meeting.

Second, That this resolution be sent to the secretaries of foreign associations with the request that it be made known to their members.

Your Committee also recommends that the following amendment to the Constitution be recommended by the COUNCIL to the Association in General Session for adoption next year :

Amendment to Article 2. Insert the words "Foreign Associates." So that it shall read :—"The Association shall consist of Members, Fellows, Foreign Associates, Patrons and Honorary Fellows."

Article 6. Add the following paragraph :

Foreign Associates shall consist of such scientists not residing in Amer-

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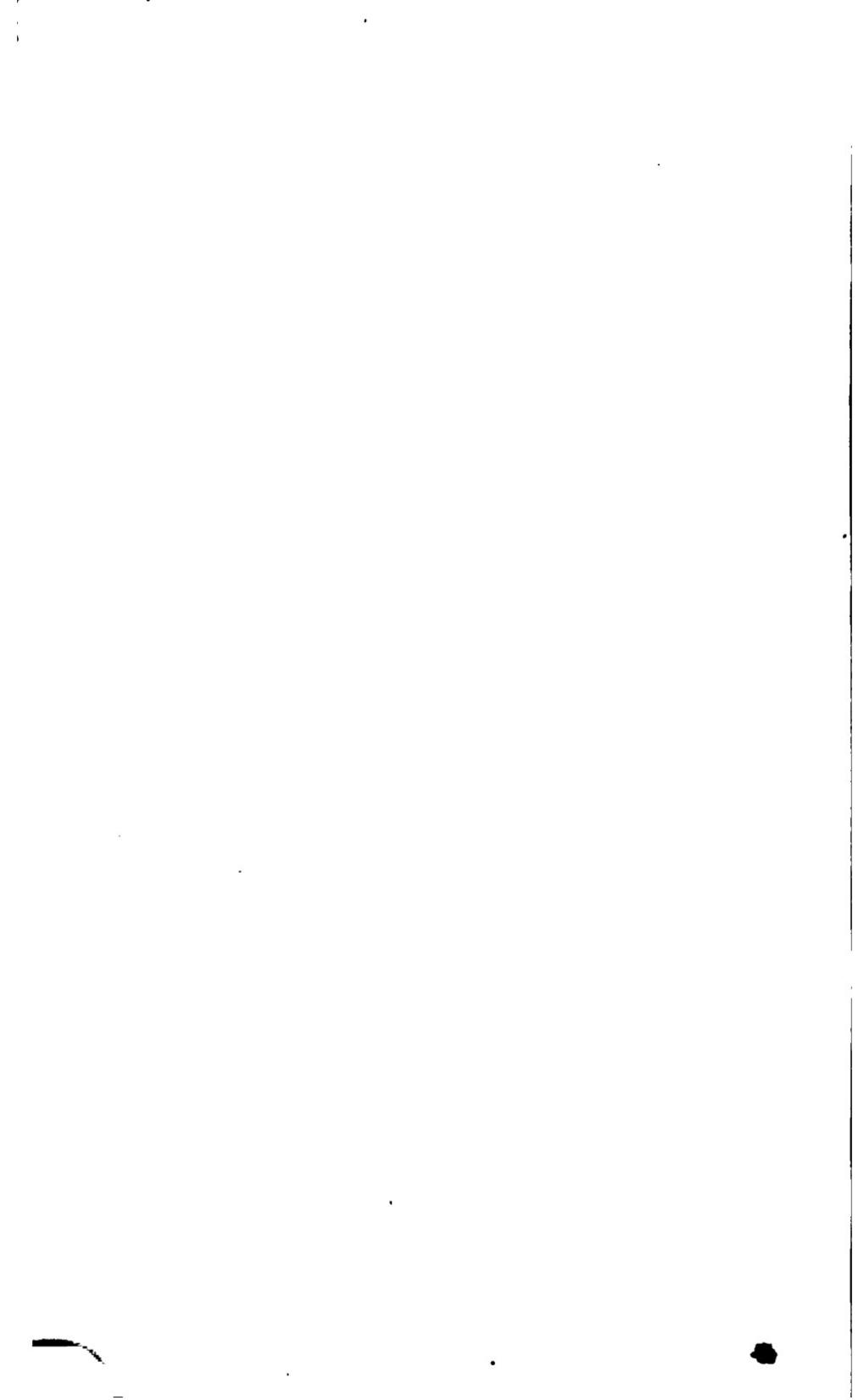
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